FINAL SUBMITTAL

ENVIRONMENTAL MONITORING REPORT

FTG-02 LAUNCH

KODIAK LAUNCH COMPLEX
KODIAK, ALASKA

CONTRACT NO. AADC-05-020
NTP NO. 010

Prepared for:

ALASKA AEROSPACE DEVELOPMENT CORPORATION
4300 B Street, Suite 101
Anchorage, Alaska 99503

6 December 2006

R&M CONSULTANTS, INC.

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ACRONYMS AND ABBREVIATIONS

AADC	Alaska Aerospace Development Corporation
ADEC	Alaska Department of Environmental Conservation
ADT	Alaska Daylight Time
ANSI	American National Standards Institute
ASL	Above Sea Level
B&K	Bruel & Kjaer
°C	Degrees Celsius
$CaCO_3$	Calcium Carbonate
cm	Centimeter
CNEL	Community Noise Equivalent Level
CO	Carbon Monoxide
dB	Decibels
dBA	Decibels with A-weighting (see Appendix D for definition)
dBC	Decibels with C-weighting (see Appendix D for definition)
ENRI	Environment and Natural Resources Institute
ESA	Endangered Species Act
GPS	Global Positioning System
h	Hours (used in 24-hour time format)
HCl	Hydrogen Chloride
Hz	Hertz (frequency in cycles per second)
FT	Flight Test
FTG	Flight Test Ground-based Interceptor
KLC	Kodiak Launch Complex
L	Liter
L_{eq}	Energy average noise level
L_{max}	Maximum Root-mean-square (RMS) noise level (see Appendix D for definition)
L_{min}	Minimum Root-mean-square (RMS) noise level (see Appendix D for definition)
L_{peak}	Absolute maximum noise level
L_{XX}	Sound level exceeded XX percent of the time
mg	Milligrams
ml	Milliliters
MRL	Minimum Reporting Limit
NIST	National Institute of Standards and Testing
NMFS	National Marine Fisheries Service
NOx	Nitrogen Oxide
pH	Potential of Hydrogen
R&M	R&M Consultants, Inc.
SEL	Sound Exposure Level
SLM	Sound Level Meters
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish & Wildlife Service
µS	MicroSiemens
µg	Microgram

SUMMARY OF KEY FINDINGS

Water Quality

Water quality monitoring was performed both prior to and soon after the FTG-02 launch, to detect any changes to stream water chemistry in the primary study area (Figure 1, Page 2) which might be attributable to rocket launch operations. The first round of monitoring was performed on 28 August 2006, four days prior to the launch. The second round of monitoring was scheduled to minimize delay after the 1 September launch and so was performed on 2 September 2006.

Pre-launch stream temperatures ranged from 10.45°C to 15.66°C. Post-launch stream temperatures ranged slightly lower from 8.62°C to 14.54°C. Specific conductivity measurements ranged from 63 to 112 µS/cm pre-launch and from 62 to 110 µS/cm post-launch. The range of pH in all streams sampled was 6.49 to 7.71 pre-launch, and 6.48 to 7.59 post-launch. In-situ surface water quality (pH, temperature, and specific conductivity) values were all normal for the time of year, and were consistent with prior recorded values for the primary study area.

Alkalinity measurements ranged from 8.7 to 15.6 mg/L in samples collected pre-launch, and from 8.0 to 15.9 mg/L in samples collected post-launch. Neither aluminum nor perchlorate was detected in samples collected during pre-launch and post-launch sampling. Given the fact that the aluminum and perchlorate remained at "non-detect" levels in streams after the launch, a general supposition can be made that the primary study area experienced no measurable change in water quality from either of these emitted products.

Water quality data gathered during the FTG-02 launch continue to indicate, as demonstrated during numerous previous environmental monitoring efforts, that no effects to general water quality result from KLC launches.

Marine Mammals

Marine mammal monitoring was performed both prior to and after the FTG-02 launch to record the abundance and distribution of Steller sea lions and harbor seals in the primary study area (Figure 1, Page 2), and to evaluate the effect of rocket noise on sea lion occupation of a traditional haulout. The traditional sea lion haulout is located on a gravel spit on the northern tip of Ugak Island. The primary monitoring efforts involve conducting aerial surveys along set transect lines to observe and count Steller sea lions and harbor seals and, when sea lions are present at the traditional haulout on Ugak Island, to use time-lapse video recording and sound pressure monitoring of the haulout to observe the reaction of sea lions to the launches.

The traditional sea lion haulout was not occupied during any of the monitoring efforts performed for the FTG-02 launch. Therefore an alternative location - a supralittoral rock haulout on the east side of Ugak Island referred to herein as East Ugak Rock – was chosen for video and noise monitoring. During pre-launch aerial surveys, three to five sea lions were observed in that location (two to four hauled out, one swimming), and on post-launch aerial surveys one to two sea lions were observed hauled out. Daylight video recording revealed that up to eight sea lions used the haulout for brief periods. On 1 September, the day of the launch, two sea lions occupied the haulout from 06:39h to 13:29h, when the video recording stopped. The launch occurred at 09:22:00h, and the noise reached the Ugak Island monitoring site at 09:22:24h and peaked from 09:22:50h to 09:22:53h. From 07:24h to 09:44h, the two sea lions laid resting on the haulout. They exhibited no reaction indicating disturbance during the launch.

Harbor seals were the most abundant marine mammal counted on the aerial surveys. Daily totals within the primary study area ranged from 495 seals pre-launch to 961 seals post-launch. The largest concentrations of harbor seals were consistently seen at two haulout sites, labeled Northeast Ugak and Southeast Ugak, located on the east side of Ugak Island. The pre-launch counts at two harbor seal haulouts were compared with counts after the launch to evaluate whether harbor seals were displaced from haulouts during the rocket launch. The total of the combined haulouts increased from a mean of 677 seals during the pre-launch period to 901 seals during the post-launch period.

The numbers of harbor seals at the haulouts during our surveys indicate that the launch did not have an obvious effect on haulout occupation, and that daily peak attendance at the haulouts was not affected negatively.

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1.0 INTRODUCTION

1.1 Background

On 1 September 2006, the U.S. Missile Defense Agency conducted the launch of its Flight Test Ground-based Interceptor (FTG)-02, or FTG-02. The test involved launching a threat-representative target missile from the Kodiak Launch Complex (KLC) – located at Narrow Cape on Kodiak Island, Alaska (Figure 1) – and an interceptor missile from Vandenberg Air Force Base in California. Although not a primary objective for this data collection flight test, an intercept of the target missile was achieved.

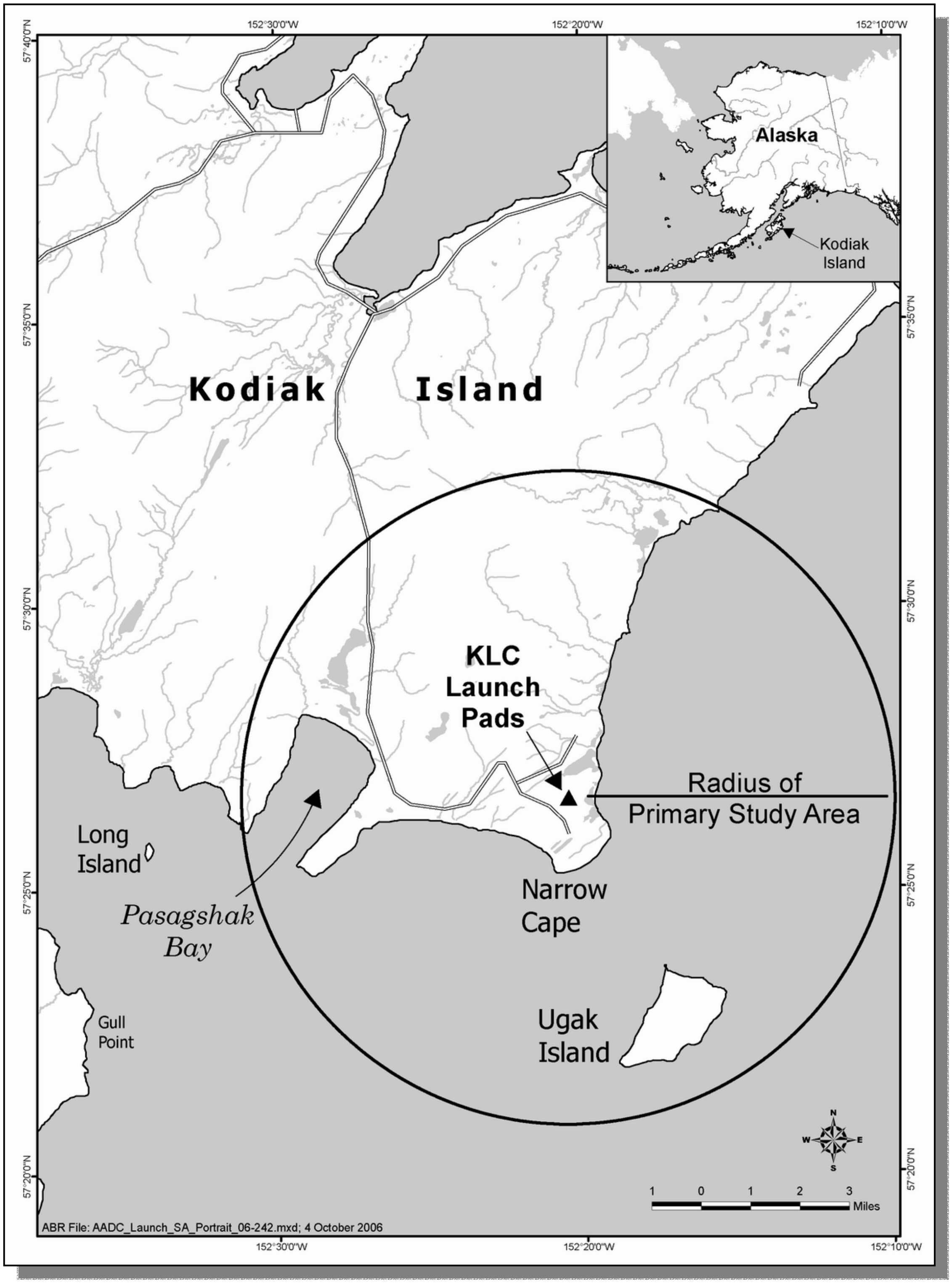
This document provides the results of mission related environmental monitoring activities performed in support of the FTG-02 target missile launch from the KLC. R&M Consultants, Inc. (R&M) conducted these studies under contract to Alaska Aerospace Development Corporation (AADC), the entity that owns and operates the KLC. R&M retained ABR, Inc. of Fairbanks, Alaska to perform the wildlife monitoring surveys, and ABR contracted directly with Michael Minor & Associates of Portland, Oregon for noise monitoring. R&M performed the water quality studies, assisted with the wildlife monitoring, and provided project management and coordination for all efforts.

The primary study area for KLC environmental monitoring focuses on the lands and waters within a circular area having approximately a six-mile radius that extends out from the launch pads at KLC (Figure 1). This study area was set in a September, 1996 meeting of AADC with representatives of the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), U.S. Department of Transportation, Federal Aviation Administration (FAA), Office of the Associate Administrator for Commercial Space Transportation, and the University of Alaska's Environment and Natural Resources Institute (ENRI). Following the referenced meeting, an Environmental Monitoring Plan, since amended, was developed and attached to the KLC's site operator license.

A requirement for detailed water chemistry analysis was added in January 2002 by the Alaska Division of Governmental Coordination, who in turn designated the Alaska Department of Environmental Conservation (ADEC) as the recipient of the data. R&M carried out the FTG-02 water quality monitoring studies in accordance with the requirements of ADEC and the findings and recommendations of the previous KLC environmental monitoring reports (ENRI 1999, 2000, 2001, 2002a,b,c,d, and 2005a,b, R&M 2006).

FIGURE 1

VICINITY MAP



Monitoring of marine mammals in the primary study area was also conducted during the FTG-02 mission, in accord with management agency requirements. Monitoring for marine mammals during launches began in 1998 with the first rocket launch from KLC (ENRI, 1999). The current monitoring protocols follow methods that are described in the KLC Environmental Management Plan (ENRI, 1998) and refined by the results of previous studies conducted by ENRI and R&M, and that have been agreed to in consultations with resource agencies (USFWS, 2006 and NMFS, 2006).

1.2 Contract Authorization

This work was completed under the terms of Agreement No. AADC-05-020 between Alaska Aerospace Development Corporation and R&M Consultants, Inc. This report is in specific fulfillment of Notice-to-Proceed No. 010.

Measurements and weights presented in this report are a combination of both U.S. customary units and International System (SI) units. By convention, water quality test results are reported as SI units. The remainder of the data are generally reported in U.S. customary units.

All times in this report are presented in 24-hour (h) Alaska Daylight Time (ADT).

2.0 WATER QUALITY MONITORING

2.1 Objectives

Water quality monitoring activities were performed in conjunction with the FTG-02 launch. The rationale for this effort comes from the fact that solid fuel rocket emissions typically contain products which, if released in sufficient quantity into the environment, have the potential to be detrimental to surface water quality. These emitted products consist chiefly of hydrogen chloride (HCl), carbon monoxide (CO), nitrogen oxides (NOx), and aluminum oxide (Al_2O_3). Because of the rapidity of the ascent of launch vehicles, most of the emitted products are released at high altitudes and are therefore dispersed broadly in the atmosphere. There is the potential, however, for minor amounts of these products to reach the earth's surface near the launch origin. Therefore the principal objective of this effort is to detect any changes to stream water chemistry in the primary study area which might be attributable to rocket launch operations. Specifically, results of the water quality monitoring are used to determine if rocket exhaust products impair surface water quality at Narrow Cape.

2.2 Methods

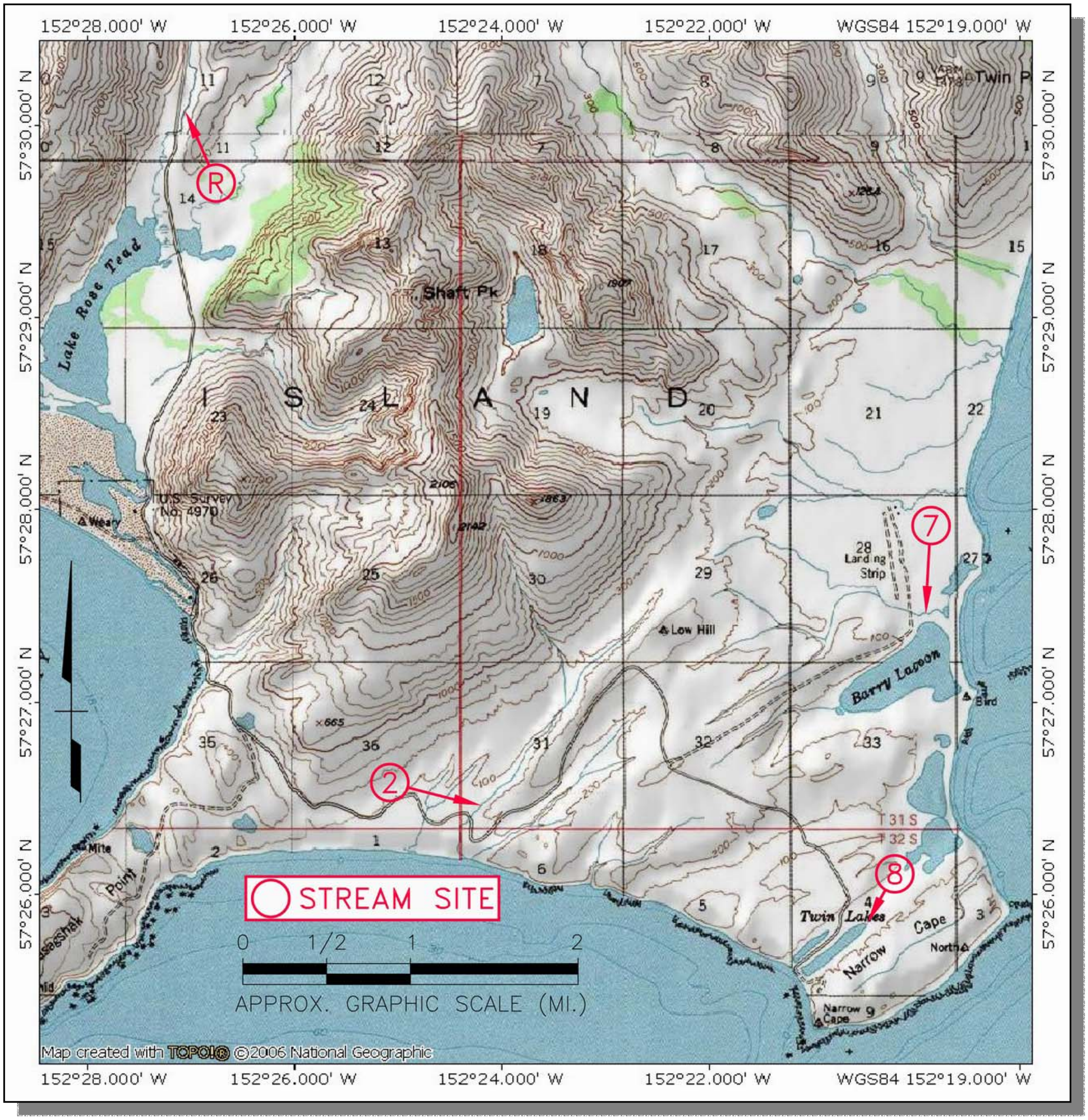
Water quality monitoring was performed both prior to and soon after the FTG-02 launch. The first round of monitoring was performed on 28 August 2006, four days prior to the launch. The second round of monitoring was scheduled to minimize delay after the 1 September launch and so was performed on 2 September 2006. Monitoring activities consisted of collecting surface water samples and real-time water quality data at three representative streams and one control, or reference, stream within the primary study area. The streams sampled for this study were Streams 2, 7, 8 and the reference stream, designated with R. Figure 2 displays the locations of each stream sampling site. Stream 2 is an unnamed waterway, originating in the mountains to the northwest of the KLC and discharging into the Pacific Ocean between Pasagshak Point and Narrow Cape. Stream 7 is an unnamed waterway, originating in low lying hills and boggy ground to the west and northwest of Barry Lagoon and discharging into the Pacific Ocean just to the north of Barry Lagoon. Stream 8 originates in boggy ground draining the northeast-southwest trending depression adjacent to the KLC launch pads. It discharges into southeastern Twin Lake, a semi-tidally influenced water body that is usually dammed from the Pacific Ocean. Stream R is an unnamed waterway that originates in the mountain pass between Pasagshak Bay and Kalsin Bay. It discharges into Lake Rose Tead which ultimately discharges into the Pacific Ocean in Pasagshak Bay.

At each sampling location, surface water temperature, pH (potential of Hydrogen), and specific conductivity were measured in-situ and real-time. This was accomplished by placing a YSI 556 Multiprobe System water meter directly into each stream and allowing sufficient time – usually about ten minutes – for all parameters to stabilize. Temperature was recorded in degrees Celsius (°C), pH was recorded on the standard unitless scale of 0 to 14, and specific conductivity was recorded as microSiemens per centimeter (µS/cm).

Water samples were also collected at each sampling location to be laboratory-analyzed for perchlorate, total alkalinity, and aluminum. Samples slated for perchlorate and alkalinity analyses were collected in clean 500-milliliter (ml) polyethylene bottles with no preservative. Samples slated for aluminum analysis were contained in clean 250-ml polyethylene bottles, each containing approximately five ml of nitric acid as a preservative. All surface water samples were packaged in coolers with ice packs and shipped to Severn Trent Laboratories, Inc. (STL) of Sacramento, California. Once received by STL, they were analyzed using United States Environmental Protection Agency (USEPA) protocols within the published hold times associated with each test method.

FIGURE 2

WATER QUALITY MONITORING SITES



Perchlorate was analyzed according to the procedures outlined in USEPA Method 314.0. It was reported in micrograms per liter (µg/L), with a minimum reporting limit (MRL) of 1.0 µg/L. Total alkalinity was analyzed according to USEPA Method 2320B. It was reported in milligrams per liter (mg/L) of calcium carbonate, with a MRL of 5.0 mg/L. Aluminum was analyzed according to USEPA Method 6020. It was reported in µg/L, with a MRL of 50 µg/L.

2.3 Results

Table 1 provides the water chemistry results for all water quality monitoring conducted for the FTG-02 launch.

2.3.1 In-Situ Analysis

Pre-launch stream temperatures measured on 28 August 2006 ranged from 10.45°C in Stream R to 15.66°C in Stream 7. Post-launch stream temperatures ranged slightly lower from 8.62°C to 14.54°C (Table 1). By the time the post launch water quality monitoring was conducted on 2 September 2006, stream temperatures had all dropped an average of 1.1°C. Since air temperatures were relatively constant over the pre-launch to post-launch period, this universal temperature drop is attributed to the heavy precipitation event of 30 August 2006. As expected, Stream 8, which is influenced by the large adjacent thermal mass of southeastern Twin Lake, experienced the smallest temperature shift between the pre-launch and post-launch sampling. Recorded temperatures were normal for this time of year.

Specific conductivity measurements in Streams 7 and 8 experienced almost no change pre-launch to post-launch, ranging from 63 to 112 µS/cm on 28 August 2006 and from 62 to 110 µS/cm on 2 September 2006 (Table 1). These are normal ranges and are consistent with prior recorded values (R&M 2006, ENRI 1999, 2000, 2001, 2002a,b,c,d, and 2005a,b). Specific conductivity measurements taken post-launch at Streams 2 and R are deemed erroneous. The data show a pre-launch range from 34 to 61 µS/cm, which is normal, and a post-launch range from 3.4 to 5.9 µS/cm. This is a difference of exactly a factor of ten. There are two likely reasons for this discrepancy, one being human error (i.e. misplacing a decimal point) in the actual recording of measurements taken by the water meter, and the other being a different measurement scale setting on the meter for the post-launch round of monitoring. When the error was discovered after personnel had returned from Kodiak, an attempt was made to recover the data stored in the water meter for clarification. This proved impossible.

The range of pH in all streams sampled was 6.49 to 7.71 pre-launch, and 6.48 to 7.59 post-launch (Table 1). This represents virtually no change between sampling events, which would be expected if no environmental disturbance to the stream occurs.

2.3.2 Laboratory Analysis

Alkalinity measurements ranged from 8.7 to 15.6 mg/L in samples collected pre-launch, and from 8.0 to 15.9 mg/L in samples collected post-launch. The one duplicate sample, collected from Stream 7 (Sample IDs S7-1D and 2D) during each sampling event, is in good agreement with the base sample from Stream 7 (Sample IDs S7-1 and 2). This is an indicator of internal consistency within the laboratory analytical data. It is used as a check to help highlight potential inconsistencies in laboratory analysis or sampling technique within environmental monitoring data sets, either from a single launch campaign or when comparing data between different campaigns.

Neither aluminum nor perchlorate was detected at the MRL in samples collected during pre-launch and post-launch sampling.

TABLE 1

ANALYTICAL RESULTS FOR WATER CHEMISTRY ANALYSIS

IN-SITU ANALYSIS				***LABORATORY ANALYSIS***			
Stream ID	**Temperature (°C)**	**Specific Conductivity (µS/cm)**	**pH**	**Sample ID**	**Aluminum (µg/L)**	**Alkalinity (mg/L)**	**Perchlorate (µg/L)**
Pre-Launch Results (28 August 2006)							
Stream R	10.45	34	7.46	SR-1	ND	8.7	ND
Stream 2	12.32	61	6.89	S2-1	ND	15.6	ND
Stream 7	15.66	63	6.49	S7-1	ND	13.3	ND
				S7-1D	ND	12.1	ND
Stream 8	14.43	112	7.71	S8-1	ND	13.3	ND
Post-Launch Results (2 September 2006)							
Stream R	8.62	(3.4)?	6.79	SR-2	ND	8.0	ND
Stream 2	11.24	(5.9)?	6.78	S2-2	ND	15.9	ND
Stream 7	14.54	62	6.48	S7-2	ND	12.2	ND
				S7-2D	ND	11.8	ND
Stream 8	14.08	110	7.59	S8-2	ND	13.7	ND

Key:

°C – degrees Celsius
µS/cm – microSiemens per centimeter
µg/L – micrograms per liter
mg/L – milligrams per liter
pH – potential of Hydrogen
D – duplicate sample, collected as consistency check on laboratory analysis
ND – not detected
? – Questionable data; see Section 2.3.1 for explanation

2.4 Discussion

In-situ surface water quality (pH, temperature, and specific conductivity) values were all normal for the time of year, and were consistent with prior recorded values for the primary study area (R&M, 2006, ENRI, 1999, 2000, 2001, 2002a,b,c,d, and 2005a,b). Based on the faulty specific conductivity data for Streams 2 and R, as described in the previous section, a new element will be added to future water quality monitoring events. To further safeguard the integrity of collected data, future in-situ surface water measurements will be stored in the water meter for post processing and comparison with hand recorded values.

Alkalinity of water is a measure of "buffering capacity", or the ability of the water to accommodate changes in pH. In the context of the water quality studies conducted for KLC launches, pre- and post-launch pH measurements serve to indicate potential impact to stream water acidity from rocket emissions, while alkalinity measurements indicate the stream's ability to respond to any potential increase in acidity. The primary indicator used to quantify alkalinity in Kodiak streams is calcium carbonate ($CaCO_3$). Higher levels of $CaCO_3$ in surface water generally show an increased ability of the water to neutralize acid. In the case of stream water near the KLC, very depressed levels of alkalinity would indicate a decreased potential to neutralize the acidic HCl constituent in solid-fuel rocket emissions. This would be important to fish and aquatic life. Alkalinity and pH measurements in the area of the KLC have been collected and analyzed for over a decade, in environmental baseline studies and throughout numerous rocket launches similar to the FTG-02 campaign. All data have consistently been within normal ranges when compared to historical information and local trends.

Laboratory measurements of aluminum and perchlorate in stream water samples were not detectable at the limits of the testing equipment and the EPA test methods (MRL of 50µg/L). Given the fact that the aluminum and perchlorate remained at "non-detect" levels in streams after the launch, a general supposition can be made that the primary study area experienced no measurable change in water quality from either of these emitted products.

Water quality data gathered during the FTG-02 launch continue to indicate, as demonstrated during numerous previous environmental monitoring efforts (R&M, 2006, ENRI, 1999, 2000, 2001, 2002a,b,c,d, and 2005a,b), that no effects to general water quality result from KLC launches.

3.0 MARINE MAMMAL MONITORING

3.1 Objectives

The focus of the marine mammal monitoring for the FTG-02 launch was to record the abundance and distribution of Steller sea lions (*Eumetopias jubatus*) and harbor seals (*Phoca vitulina*) in the primary study area, and to evaluate the effect of rocket noise on sea lion occupation of a traditional haulout. The traditional sea lion haulout is located on a gravel spit on the northern tip of Ugak Island (Figure 1). Monitoring of Steller sea lions has occurred during launches from the KLC since 1998. The primary monitoring method involves conducting aerial surveys along set transect lines to observe and count Steller sea lions. When the animals are present at the traditional haulout on Ugak Island, time-lapse video recording and sound pressure monitoring of the haulout are to be used to observe the reaction of sea lions to the launches. Monitoring of harbor seals has occurred since February 2006, when they were added to the list of focal species for marine mammal monitoring efforts for the previous launch (FT 04-1). Harbor seals are recorded simultaneously with sea lions during aerial surveys, so that additional species-specific surveys are not required (NMFS, 2006). Although all marine mammal observations have been recorded during previous launch aerial surveys, aerial transects specifically designed for the purpose of sampling northern sea otters (*Enhydra lutris*) were added to the monitoring efforts only for the previous FT 04-1 launch.

The array of species to be monitored during launches was originally chosen based on concerns expressed by NMFS, which has management responsibility for Steller sea lions and harbor seals, and by the USFWS, which has management responsibility for northern sea otters. All three species have suffered regional population declines over several decades. In 1990 the Steller sea lion was listed as threatened, throughout its range, under the Endangered Species Act (ESA) (55 FR 12645, 55 FR 13488, 55 FR 50005). The Steller sea lion was reclassified in 1997 into two distinct population segments under the Endangered Species Act (62 FR 24345), with the western U.S. stock, to which Kodiak sea lions belong, being listed as endangered. Harbor seals also underwent large declines in the Kodiak archipelago from the 1970s to the 1990s, but numbers there increased from 1993 to 2001 (Small et al., 2003). Harbor seals have not been listed under the Endangered Species Act, nor have they been listed as depleted under the Marine Mammal Protection Act.

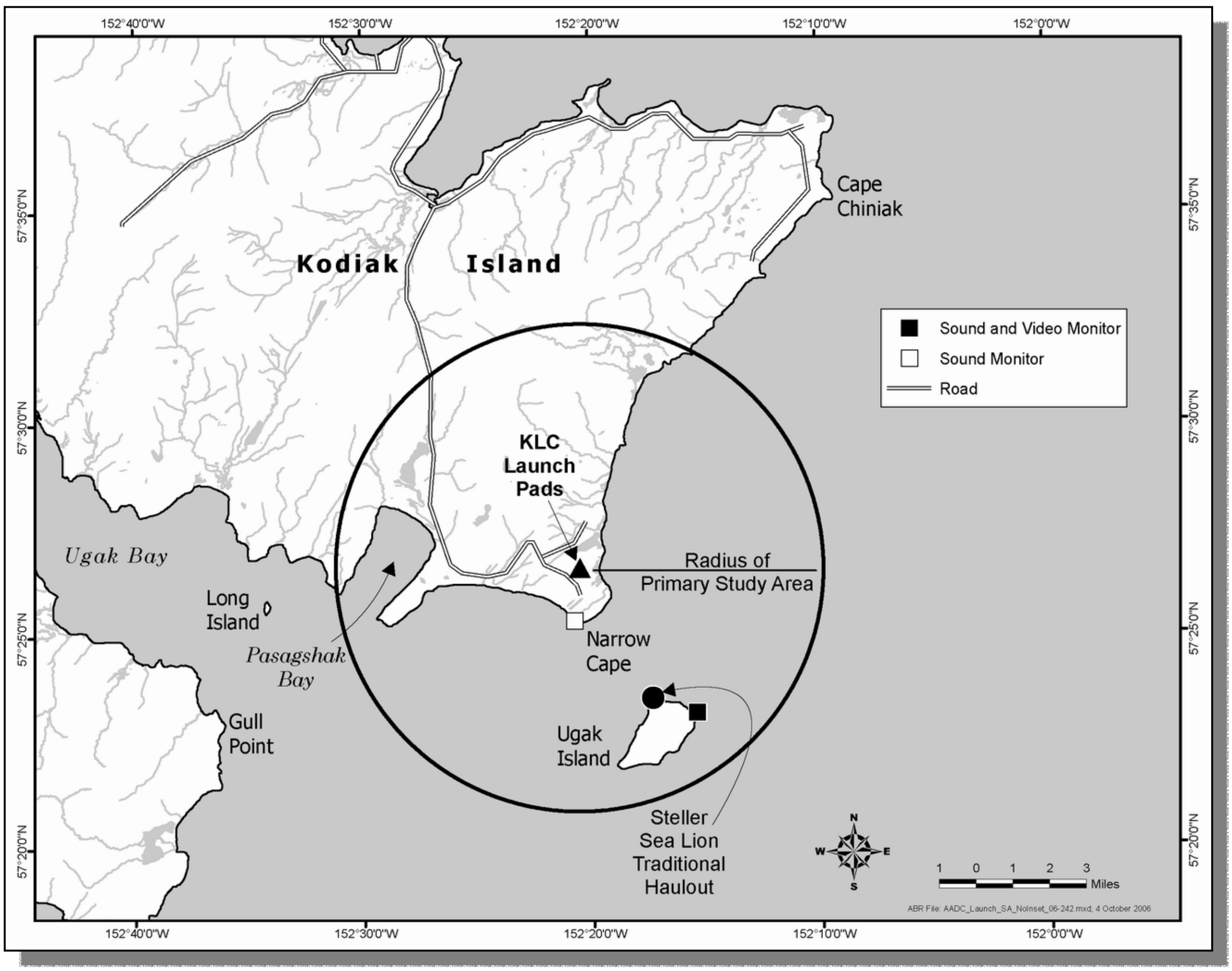
The southwestern population segment of northern sea otters (including the Kodiak archipelago) was listed as threatened in 2005 after declining approximately 55% to 67% since 1976 (70 FR 46366-46386). Early in 2006, just prior to commencement of the FT 04-1 launch campaign, USFWS and AADC concluded an informal consultation on northern sea otters under Section 7 of the ESA. The USFWS concluded with a decision that rocket operations at Narrow Cape were not likely to adversely affect sea otters. AADC nonetheless voluntarily conducted the sea otter aerial survey during the FT 04-1 campaign to close the administrative record. Small numbers of sea otters (maximal count = 8 sea otters) were seen on that survey, and the aerial surveys specifically for sea otters were discontinued after that launch (R&M, 2006).

3.2 Methods

The primary study area for marine mammals was set by NMFS and USFWS in 1996. It encompasses approximately a six-mile radius around the KLC launch pads, extending along the shoreline from the base of Cape Chiniak to Pasagshak Bay (Figure 3). AADC has authorized the inclusion of certain aerial survey transect lines that extend beyond the six-mile radius of the primary study area (Figure 4) for the sake of completeness and consistency with prior studies.

FIGURE 3

PRIMARY STUDY AREA FOR MARINE MAMMAL SURVEYS AND NOISE AND VIDEO MONITORING SITES



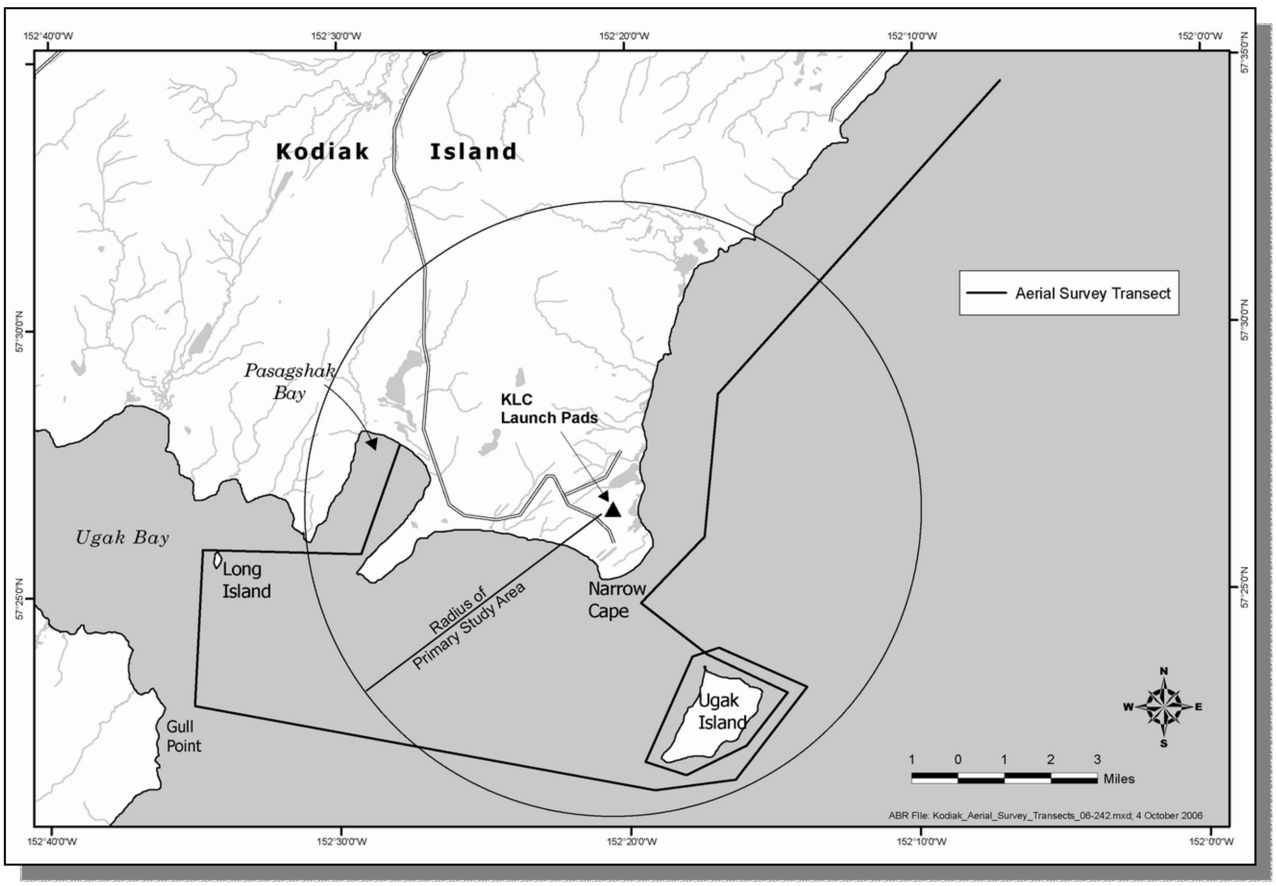
3.2.1 Aerial Surveys

Marine mammal abundance and distribution were recorded during aerial surveys flown in Cessna 206 and Found Bush Hawk aircraft on floats. The aerial survey route designed for Steller sea lions and harbor seals (Figure 4) was flown using a Global Positioning System (GPS) for navigation. The survey schedule called for daily surveys three days prior to and three days following the FTG-02 launch, weather conditions permitting. Surveys were flown within two hours of the daytime low tide or within two hours of solar noon. Solar noon was 13:09h to 13:11h each day during the survey period.

The aerial surveys were flown at 500 feet above sea level (ASL) and 80 to 90 nautical miles per hour. In accord with stipulations from NMFS, the aircraft was kept at least a ¼-mile from known haulouts. Observation conditions (wind speed and direction, visibility, cloud cover, and wave height) were recorded for each survey. Two observers, one seated in the right front of the aircraft and one in the left rear, recorded the number of adults and juveniles (or unknowns), species (or higher taxa), time, transect number, and perpendicular distance from the transect line

FIGURE 4

STUDY AREA INCLUDING AERIAL SURVEY TRANSECTS



of all marine mammals observed regardless of distance from the aircraft. When species could not be determined on the initial observation, the aircraft was diverted from the transect line to obtain a closer look and possible identification. Observation locations were recorded on copies of U.S. Geological Survey 1:63,360 scale quadrangle maps, digitally rescaled to approximately 1:125,000, and waypoints were recorded on a GPS. The waypoints and distance from the transect line for each observation were used to map estimated locations after the surveys. Digital photographs of large groups of seals were taken with a Nikon D70 camera, equipped with a 70 to 300 millimeter zoom lens and set to a shutter speed priority of 1/1000th of a second. Images were viewed on a personal computer and counts of seals were summarized from sets of overlapping images. Locations and associated attribute data for marine mammals were entered into a geodatabase in ARC 8 (Environmental Systems Research Institute).

3.2.2 Real-Time Video Monitoring

The video monitoring equipment and two noise monitors (see Section 3.2.3), were deployed on 30 August 2006, the evening before the scheduled launch. When the launch was postponed to 1 September 2006, the equipment was revisited to replace batteries on 31 August. It was retrieved at 16:40h on 1 September 2006, after the launch occurred. The recorder was scheduled to record from sunrise to sunset. The video equipment and one sound level meter were deployed on the northeast end of Ugak Island and the other sound level meter was deployed at Narrow Cape (Figure 3). The monitoring location on the northeast end of Ugak Island is a deviation from the traditional sea lion haulout location described above in Section 3.1. The traditional haulout was not occupied this launch, and so the alternate location was chosen. A Sony V18NS camera was connected to a Sony S-VHS time-lapse recorder set to record at 0.2-second intervals on a ST-120 S-VHS cassette tape. The system was powered by two 12-volt, 33-amp-hour batteries. Time and date stamps on the recorded images were used to assign noise data records from the sound monitors to video images. The video recorder clock was synchronized with the sound monitor clocks prior to recording. Transportation to the site was provided by a Bell 206 helicopter.

3.2.3 Sound Pressure Monitoring

Noise measurements were taken in accordance with the American National Standards Institute (ANSI) procedures for community noise measurements. The equipment used for noise monitoring consisted of two Bruel & Kjaer (B&K) Type 2260 Sound Level Meters (SLMs). The meters were calibrated prior to and after the measurement period using a B&K Type 4231 Sound Level Calibrator. Calibration varied by less than 0.1 decibels (dB) during the measurement period. Complete system calibration is performed on an annual basis by B&K Instruments, and system calibration is traceable to the National Institute of Standards and Testing (NIST). The system meets or exceeds the requirements for an ANSI Type 1 noise measurement system. The reader is referred Appendix D for information supporting this and subsequent noise sections.

Two systems were deployed and used to monitor the FTG-02 launch. One system was placed approximately 0.9 miles from the launch site, along Narrow Cape, and the second meter was placed with the video system on the northeast end of Ugak Island, approximately 4.6 miles from the KLC launch site (Figure 3). The sound level meters were placed in weatherproof cases that included batteries for long-term unattended operation and desiccant packs to control moisture. The B&K 2260 SLMs were set to record sound levels in one-second intervals and store the data to a compact flash card. The meters stored one-second, A-weighted L_{eq}, L_{max}, L_{min}, and sound exposure level (SEL) along with the C-weighted L_{eq} and L_{peak} over the entire measurement period. In addition, the meters also recorded and stored the unweighted L_{eq} and L_{max} in 1/3-octave bandwidths.

The systems were set to trigger (identify) one-second L_{eq} noise levels above 70 dBA with a duration of more than three seconds as an event. They stored the measurement descriptors described above and recorded the noise event as a Windows compatible WAV file. Noise level data were downloaded into the B&K Type 7820 software package for post processing. This package allows for easy viewing and analysis of the measured noise level and also allows the user to listen to the noise event and export data to Microsoft Excel for post processing.

3.3 Results

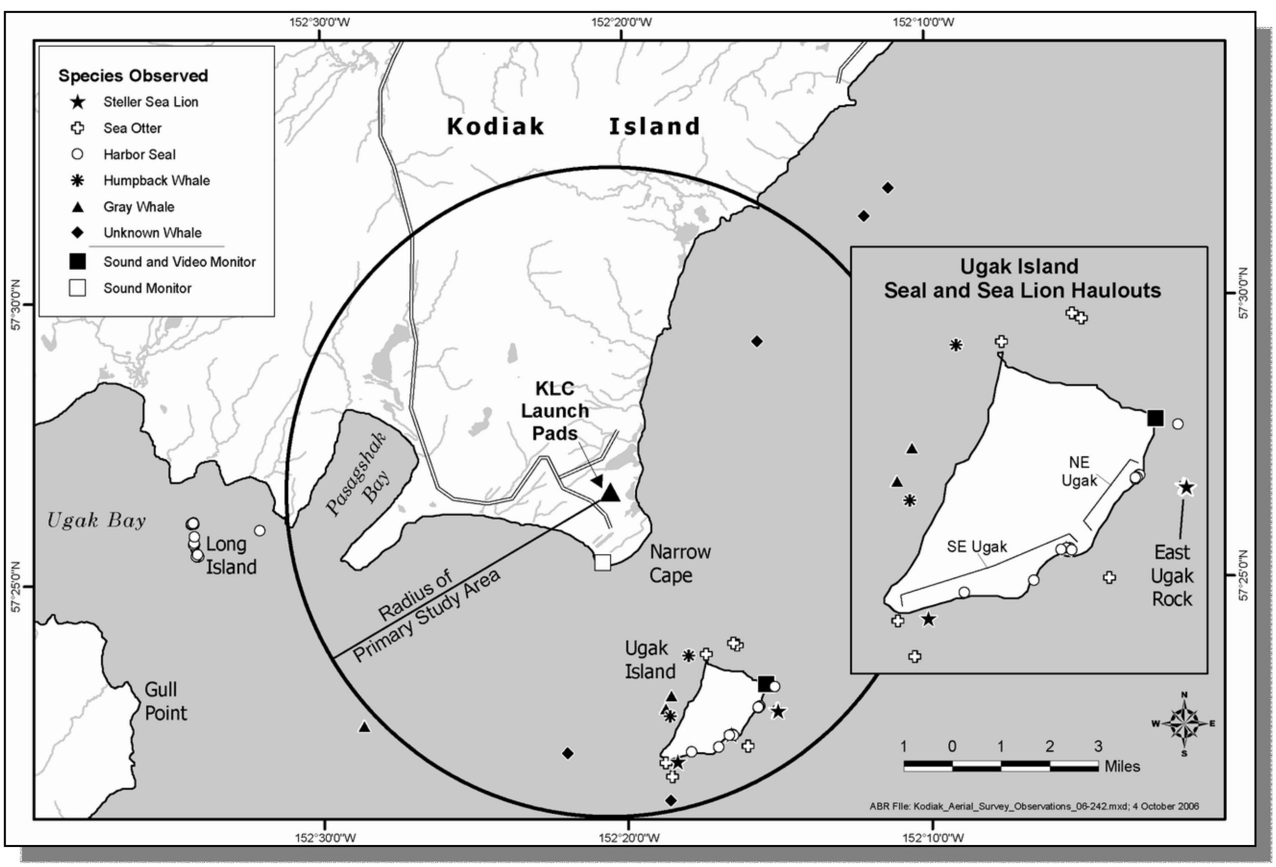
This section presents the data gathered during all marine mammal monitoring efforts.

3.3.1 Aerial Surveys

Aerial surveys were flown from 28 August through 3 September 2006 with one survey canceled by low ceilings and heavy fog on 30 August (Appendix B). Three surveys were completed before the launch occurred on 1 September at 09:22:00h and three surveys were completed post-launch. Marine mammal locations noted during the aerial surveys are displayed below in Figure 5, and are set forth in detail in the following sections.

FIGURE 5

MARINE MAMMAL LOCATIONS FROM AERIAL SURVEYS



3.3.1.1 Steller Sea Lions

Steller sea lions did not use the spit on the north end of Ugak Island (the traditional haulout, Figure 3) during any of the aerial surveys performed for the FTG-02 launch. However, one to four Steller sea lions used a supralittoral rock on the east side of Ugak Island (labeled East Ugak Rock, Figure 5) during all six aerial surveys. On pre-launch aerial surveys, two to four sea lions were hauled out in that location, and on post-launch aerial surveys one to two sea lions were hauled out. In addition, single sea lions were observed swimming at approximately the same location on 28 and 31 August 2006 (Figure 5, Table 2).

TABLE 2

MARINE MAMMAL COUNTS FROM AERIAL SURVEYS IN PRIMARY STUDY AREA

Date	Steller Sea Lion [a]	Harbor Seal [b]	Sea Otter	Gray Whale	Humpback Whale	Unidentified Whale
Pre-launch						
28 Aug 06	3	495	0	0	0	2
29 Aug 06	4	652	4	0	0	0
31 Aug 06	5	901	0	0	0	0
Post-launch						
1 Sep 06	2	961	1	0	0	0
2 Sep 06	1	954	0	2	1	0
3 Sep 06	1	789	2	0	1	0
Total	16	4,752	7	2	2	2
Mean	2.67	792.00	2.33	1.17	0.33	0.33
Std. Error	0.67	76.27	0.62	0.65	0.33	0.21

Key: [a] Includes count of one sea lion swimming on 28 August and one swimming on 31 August.
[b] Includes counts from photos of haulouts; all other are visual counts from the aircraft.

3.3.1.2 Harbor Seals

Harbor seals were the most abundant marine mammal counted on the aerial surveys (Figure 5, Table 2). Daily totals within the primary study area ranged from 495 seals on 28 August 2006 to 961 seals on 1 September 2006. All counts of ≥ 25 seals were made from digital images taken from the aircraft, which produced higher counts than visual estimates from the aircraft (R&M, 2006).

The largest concentrations of harbor seals were consistently seen at two haulout sites, labeled Northeast Ugak and Southeast Ugak, located on the east side of Ugak Island (Figure 5). In a previous report (R&M, 2006) these same sites were referred to as Southeast 1 and Southeast 2, respectively. All but 18 of the harbor seals in the primary study area were located at the Northeast and Southeast Ugak haulouts. The additional 18 harbor seals were seen on a small supralittoral rock near the northeast corner of Ugak Island during the first aerial survey only. The maximal counts of harbor seals at these two sites came from photographs taken on 1 September 2006 (480 seals at Northeast Ugak) and on 2 September 2006 (591 seals at Southeast Ugak). The highest daily count of harbor seals at the two haulouts combined was 961 seals on 1 September 2006, and the lowest count was 477 seals on 28 August 2006. Relatively large numbers of seals (range, 154 to 221) also were seen daily at Long Island, which was outside the primary study area (Figure 5). A smaller haulout site just outside Pasagshak Bay (outside the primary study area) was occupied once on 29 August 2006 by 23 seals. Total counts of harbor seals along the aerial survey transect, including areas outside the primary study area, are presented in Appendix C.

TABLE 3

COMPARISON OF PRE- AND POST-LAUNCH AERIAL SURVEY COUNTS OF HARBOR SEALS AND STELLER SEA LIONS ON HAULOUTS

Launch Period Date	Harbor Seals [a]		Steller Sea Lions
	Northeast Ugak	**Southeast Ugak**	**East Ugak Rock**
Pre-launch			
28 Aug 06	167	310	2
29 Aug 06	254	398	4
31 Aug 06	455	446	4
Mean	292.00	384.67	3.33
Standard Error	85.28	39.82	0.67
Post-launch			
1 Sep 06	480	481	2
2 Sep 06	363	591	1
3 Sep 06	364	425	1
Mean	402.33	499.00	1.33
Standard Error	38.83	48.76	0.33

Notes: Comparison of harbor seal counts from digital images taken at three haulout sites during pre- and post-launch aerial surveys, Kodiak Island, Alaska, 2006. See Figure 5 for haulout locations.

Key: [a] Counts from photos of haulouts; all others are visual counts from the aircraft

The pre-launch counts at two harbor seal haulouts were compared with counts after the launch (Table 3) to evaluate whether harbor seals were displaced from haulouts during the rocket launch. For consistency, all of the surveys were flown within two hours of low tide (Appendix

B). Differences between pre- and post-launch counts were not tested statistically, because small sample size and high variance in the counts would have made tests inconclusive. The total of the combined haulouts increased from a mean of 677 seals (n = 3 surveys) during the pre-launch period to 901 seals (n = 3 surveys) during the post-launch period. Counts at the Northeast Ugak haulout were about 1/3 higher post-launch (mean = 402 seals) than pre-launch (mean = 292 seals). Counts at the Southeast Ugak haulout similarly increased by more than 100 seals from the pre-launch period (mean = 385 seals) to the post-launch period (mean = 499 seals).

3.3.1.3 Northern Sea Otters

Sea otters were recorded in small groups on three of the six surveys (Figure 5, Table 2). The largest group was two otters seen on 3 September 2006. We note that the survey route and flight altitude (500 feet ASL) were designed to count Steller sea lions and minimize disturbance to that species, and therefore were not an optimal design for counting sea otters.

3.3.1.4 Whales

Small numbers of whales were observed on several surveys (Figure 5, Table 2). Only two species were identified, gray whales (*Eschrichtius robustus*) and humpback whales (*Megaptera novaeangliae*), but most of the unidentified whales were likely gray or humpback whales which were too far away to identify or which did not resurface when the airplane flew near them. No more than two whales were seen on any one survey, far fewer than were seen during the FT 04-1 launch in February 2006, when 27 gray whales were seen on one survey.

3.3.2 Real-Time Video Monitoring

The traditional Steller sea lion haulout on the northern spit at Ugak Island (ENRI, 2000) was not occupied during the period of 28 August through 3 September 2006. Therefore an alternative monitoring site overlooking East Ugak Rock was chosen on the northeast side of Ugak Island (Figure 5). East Ugak Rock was a supralittoral rock used by one to four sea lions during aerial surveys.

Concurrent video and noise monitoring were conducted on 30 August through 1 September 2006 at the new monitoring site. The camera began recording at 19:33h on 30 August 2006 and terminated at 13:29h on 1 September, when the recorder ran out of tape. Batteries were exchanged on 31 August. Light conditions before 06:30h and after 21:30h were generally inadequate for discernible images. The camera system performed well during adequate light conditions.

TABLE 4

VIDEO LOG OF STELLER SEA LION COUNTS AT EAST UGAK ROCK

Date	Time (ADT)	Duration[a]	No. of Sea Lions	Remarks	Date	Time (ADT)	Duration[a]	No. of Sea Lions	Remarks
30-Aug	19:33:18h	2:06:00	1	fog	31-Aug	13:34:58h	0:03:38	6	
30-Aug	21:39:18h	--	1	dark	31-Aug	13:38:36h	0:36:36	7	
31-Aug	6:35:38h	3:58:57	1	light	31-Aug	14:15:12h	0:02:56	8	
31-Aug	10:34:35h	0:01:38	2		31-Aug	14:18:08h	0:07:51	7	
31-Aug	10:36:13h	0:02:12	1		31-Aug	14:25:59h	1:05:51	8	
31-Aug	10:38:25h	0:00:51	2		31-Aug	15:31:50h	0:05:27	7	
31-Aug	10:39:16h	0:04:07	1		31-Aug	15:37:17h	0:18:17	6	
31-Aug	10:43:23h	0:03:02	2		31-Aug	15:55:34h	0:03:54	7	
31-Aug	10:46:25h	0:04:05	3		31-Aug	15:59:28h	0:34:40	6	
31-Aug	10:50:30h	0:09:22	2		31-Aug	16:34:08h	0:10:10	5	
31-Aug	10:59:52h	0:05:55	3		31-Aug	16:44:18h	1:26:15	4	
31-Aug	11:05:47h	0:32:15	4		31-Aug	18:10:33h	0:03:57	3	
31-Aug	11:38:02h	0:11:30	5		31-Aug	18:14:30h	0:00:06	2	
31-Aug	11:49:32h	0:20:35	3		31-Aug	18:14:36h	1:55:26	1	
31-Aug	12:00:30h	--	3	airplane overflight[b]	31-Aug	18:25:00h	--	1	helicopter at Ugak I.[c]
31-Aug	12:06:38h	--	3	airplane overflight[b]	31-Aug	20:10:02h	0:27:08	0	
31-Aug	12:11:18h	--	3	airplane overflight[b]	31-Aug	20:37:10h	0:00:30	1	
31-Aug	12:10:07h	0:04:38	4		31-Aug	20:37:40h	0:52:05	0	
31-Aug	12:14:45h	0:11:10	5		31-Aug	21:29:45h	--	0	dark
31-Aug	12:25:55h	0:19:31	4		1-Sep	6:39:00h	6:50:50	2	light
31-Aug	12:45:26h	0:02:53	5		1-Sep	9:22:00h		2	rocket launch
31-Aug	12:48:19h	0:06:33	6		1-Sep	13:29:50h		2	end
31-Aug	12:54:52h	0:40:06	7						

Key:
[a] Duration is the uninterrupted length of time a specific number of sea lions was on the haulout.
[b] Overflight by Found Bushhawk during marine mammal aerial survey.
[c] Helicopter landed at monitoring site to exchange batteries for video recorder.

Steller sea lions occupied the monitored haulout during all but two hours of daylight video recording (Table 4). Although only one to four sea lions were at the haulout during the aerial surveys, up to eight sea lions used the haulout for brief periods during video monitoring. One sea lion occupied the haulout on 30 August 2006, the evening the video camera was installed. The number of sea lions on 31 August increased from one to a peak of eight sea lions at 14:15h and 14:25h and then steadily declined to zero at 20:10h. On 1 September, the day of the launch, two sea lions occupied the haulout from 06:39h to 13:29h, when the video recording stopped.

On 1 September 2006, the two sea lions on the haulout exhibited no reaction indicating disturbance during the launch. The launch occurred at 09:22:00h and the noise reached the Ugak Island monitoring site at 09:22:24h and peaked from 09:22:50h to 09:22:53h (see Section 3.3.2). Noise at the Ugak Island monitoring site peaked at 83.1 dBA L_{max} and 105.6 dBC L_{peak}. From 07:24h to 09:44h, the two sea lions laid resting on the haulout. At 09:44h, they sat up and interacted for 1 min 12 seconds, then laid and rested until monitoring ceased at 13:29h.

Two other potential disturbances were recorded at the video monitoring site. Aerial surveys were conducted from a fixed wing aircraft during video monitoring on 31 August 2006. The aircraft passed by the haulout three times at 500 feet ASL between 12:00h and 12:11h (Table 4). Three sea lions were seen in the video and remained on the haulout with no change in activity. A fourth sea lion was seen from the aircraft which was not within the view of the video camera. Also on 31 August, a helicopter landed at the Ugak Island monitoring location (approximately 0.6 mi from East Ugak Rock haulout) to replace batteries in the recording equipment. The helicopter landed at 18:25h and departed at approximately 18:40h. Although the number of sea lions using the haulout decreased from eight at 14:25h to zero at 20:10h, the helicopter did not appear to cause the departures. The numbers decreased incrementally through the afternoon, remained at one sea lion from 18:14h to 20:10h, when the last sea lion departed, except for one that returned briefly at 20:37h. We suspect that other factors, such as increasing tide levels (low tide was at 12:07h, Appendix B), caused the sea lions to leave the haulout one at a time.

3.3.3 Sound Pressure Monitoring

The sound data were analyzed using the B&K analysis software and tables were compiled using Microsoft Excel. Graphs of the measured noise levels along with the audio recordings were used to determine the exact moment of launch for each site, and to determine when the rocket was no longer the dominant noise source. Monitored noise levels for the two measurement sites are presented in the following two sections.

3.3.3.1 Narrow Cape Noise Levels

Using the audio recording and the clock in the sound level meter, launch noise was registered at the Narrow Cape noise monitor station at 09:22:01h. The actual launch ignition occurred at 09:22:00h. The period of time during which noise levels at Narrow Cape were above the general ambient noise was approximately one minute and 23 seconds. The maximum noise level over the launch period was 110.0 dBA L_{max}, or 128 dBC L_{peak}. The SEL over the one minute 23-second period was 112.5 dBA. Prior to the launch, one second L_{eq} noise levels varied from 40 dBA to 53 dBA, with most noise due to gusting winds. There were no other noise sources in the area at the time of the launch except an occasional songbird chirping.

Figure 6 is a composite graph of the A-weighted L_{eq}, L_{max} and L_{min}, along with the C-weighted L_{peak}. The selection shown in grey is the one minute 26-second period when the rocket was clearly audible and a major noise source at this site. The three colored bars at the top of the graph indicate the start and stop times of the sound level meter trigger for the event (red) and audio recording (yellow), and the time from the initial blast until noise levels returned to what would be considered ambient noise at this site (blue). The red cursor line is set to the loudest one second of the measurement period as measured by the C-weighted L_{peak} sound level. Table 5 provides a detailed summary of the measured noise levels shown in Figure 6.

FIGURE 6

COMPOSITE NOISE LEVEL GRAPH FOR NARROW CAPE

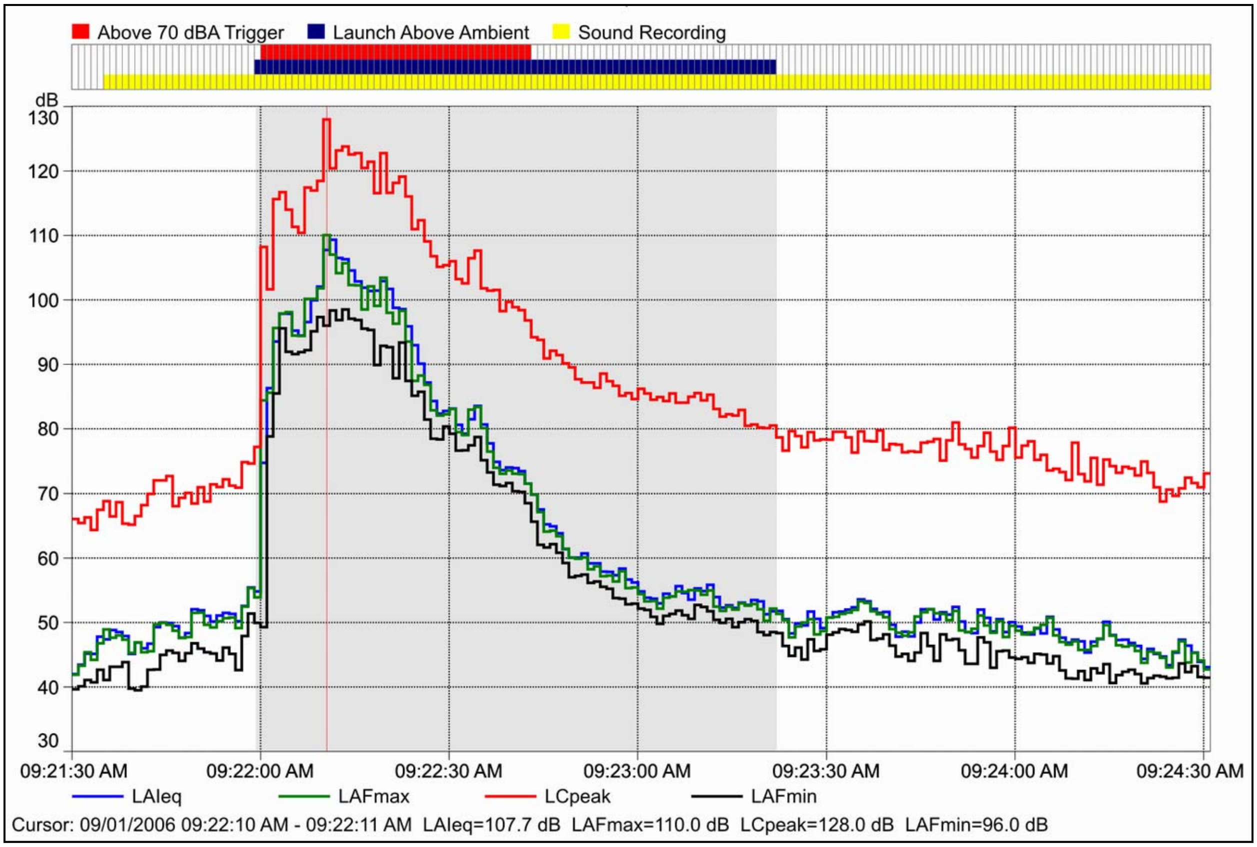


TABLE 5

NOISE MONITORING SUMMARY DATA AT NARROW CAPE

Name	Start Time (1 Sep 2006)	Duration	L_{eq}	L_{max}	L_{min}	L_{peak} [a]	SEL
Total (3-minute period)	09:21:30h	0:03:00	89.9	110.0	39.5	128	112.5
Above Trigger Level	09:21:59h	0:00:43	96.1	110.0	49.3	128	112.5
Blast to Ambient	09:21:59h	0:01:23	93.3	110.0	48.1	128	112.5
Sound Recording	09:21:35h	0:02:56	90.0	110.0	39.5	128	112.5

Key: [a] L_{peak} measured in dBC, all others in dBA

In addition to the one-second broadband data, one-second 1/3-octave unweighted L_{max} and L_{eq} were also recorded over the entire measurement period. Three graphs of the 1/3-octave data were developed to provide a summary of the 1/3-octave readings:

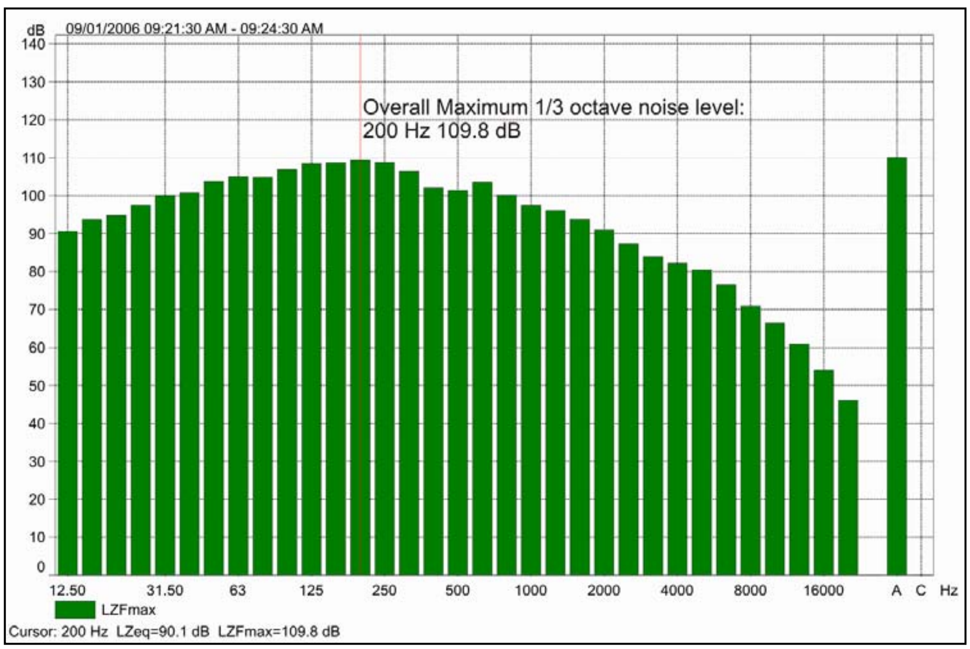
- Unweighted maximum measured noise levels for each 1/3-octave bandwidth over the entire three-minute analysis period at Narrow Cape (Figure 7).

- Unweighted energy averaged (L_{eq}) noise levels for each 1/3-octave bandwidth over the entire three-minute analysis period at Narrow Cape (Figure 8).

- Unweighted 1/3 octave noise levels for the one-second interval with the highest overall C-weighted sound level, which occurred at 09:22:10h at Narrow Cape (Figure 9).

FIGURE 7

UNWEIGHTED MAXIMUM (L_{MAX})
1/3-OCTAVE NOISE LEVELS AT NARROW CAPE



All three of the graphs show clear peaks between 63 and 250 Hz. Low frequency energy is expected for this type of noise source. The maximum 1/3-octave noise level during the analysis period was 109.8 dB (linear) at 200 Hz. The maximum 1/3-octave L_{eq} of 90.1 dB (linear) also was recorded at 200 Hz. A 1/3-octave noise level at 250 Hz of 105.8 dB L_{eq} and 108.1 dB L_{max} (linear) occurred during the one-second maximum peak level of 128 dBC.

FIGURE 8

UNWEIGHTED 1/3-OCTAVE ENERGY AVERAGE (L_{EQ})
NOISE LEVELS AT NARROW CAPE

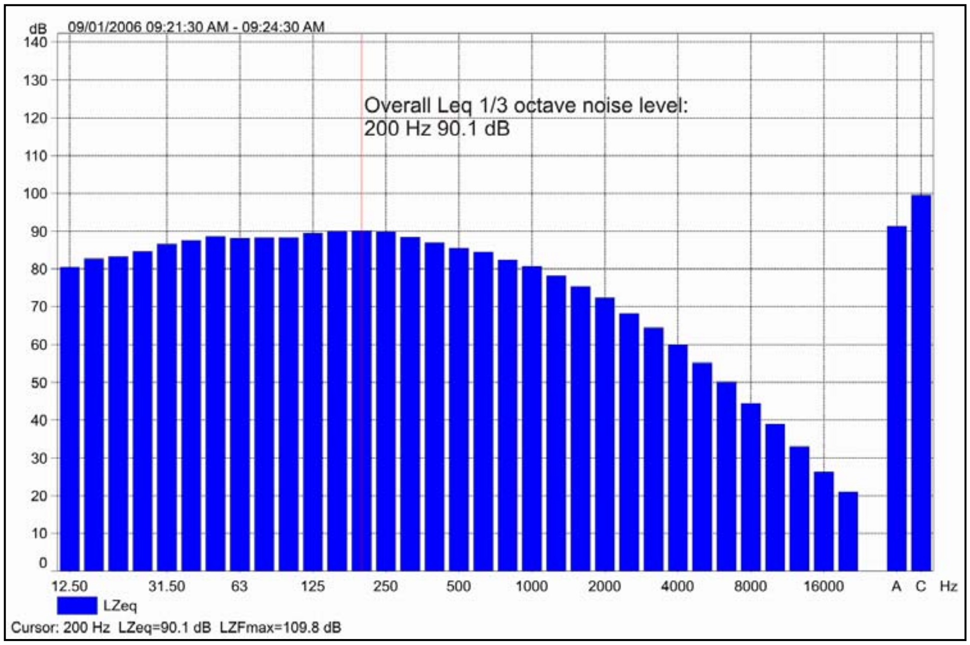
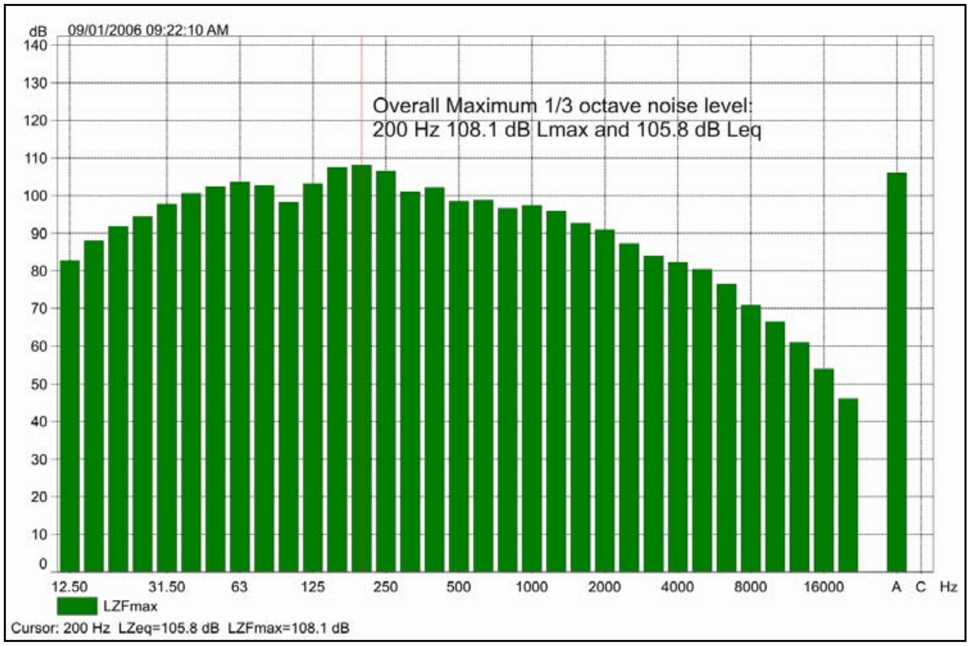


FIGURE 9

UNWEIGHTED 1/3-OCTAVE C-PEAK MAXIMUM
NOISE LEVELS AT NARROW CAPE



3.3.3.2 Ugak Island Noise Levels

Using the audio recording and the clock in the sound level meter, launch noise was registered at the Ugak Island noise monitoring site at 09:22:24h. Again, the actual launch time officially occurred at 09:22:00h. The sound delay can be accounted for by the distance between the launch pad and the noise meter and atmospheric conditions at the time of the launch. The period of time during which noise levels at Ugak Island were above the general ambient noise was approximately one minute and eight seconds. The maximum noise level over the launch period was 83.1 dBA L_{max}, or 105.6 dBC L_{peak}. The SEL over the one minute and eight second period was 90.1 dBA. Prior to the launch, one-second L_{eq} noise levels varied from 53 dBA to 61 dBA, with most noise due to gusting winds. There were no other noise sources in the area at the time of the launch.

Figure 10 is a composite graph of the A-weighted L_{eq}, L_{max} and L_{min}, along with the C-weighted L_{peak}. The selection shown in grey is the one minute and eight-second period where the rocket would be audible at this site. As with Figure 6, the three colored bars at the top of the graph indicate the start and stop times of the sound level meter trigger for the event (red) and audio recording (yellow), and the time from the initial blast until noise levels returned to what would be considered ambient noise at this site (blue). The cursor is set to the loudest one second of the measurement period as measured by the C-weighted L_{peak} sound level. Table 6 provides a detailed summary of the measured noise levels given on Figure 10.

FIGURE 10

COMPOSITE NOISE LEVEL GRAPH FOR UGAK ISLAND

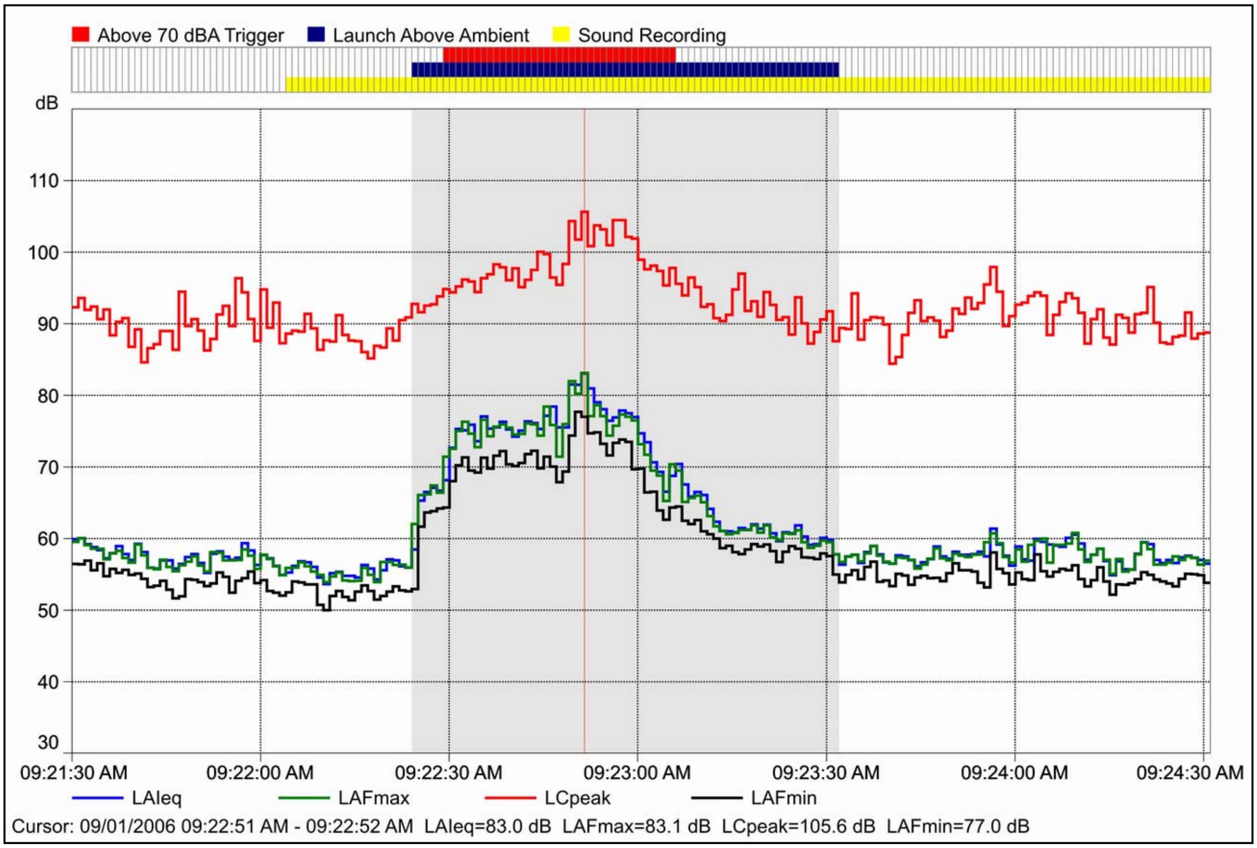


TABLE 6

NOISE MONITORING SUMMARY DATA AT UGAK ISLAND

Name	Start Time (1 Sep 2006)	Duration	L_{eq}	L_{max}	L_{min}	L_{peak} [a]	SEL
Total (3-minute period)	09:21:30h	0:03:00	67.7	83.1	50.0	105.6	90.3
Above Trigger Level	09:22:29h	0:00:37	74.2	83.1	62.6	105.6	89.9
Blast to Ambient	09:22:24h	0:01:09	71.8	83.1	52.9	105.6	90.1
Sound Recording	09:22:04h	0:02:27	68.5	83.1	50.0	105.6	90.2

Key: [a] L_{peak} measured in dBC, all others in dBA.

The same three 1/3-octave graphs plotted for the Narrow Cape monitoring site were also plotted for the Ugak Island monitoring site:

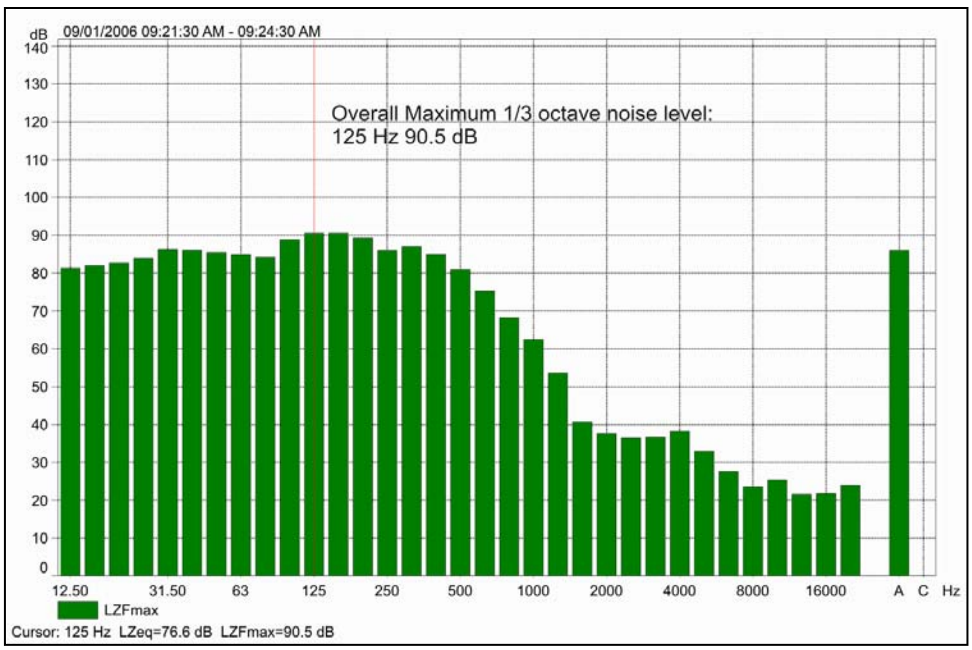
- Unweighted maximum measured noise levels for each 1/3-octave bandwidth over the entire three-minute analysis period (Figure 11).

- Unweighted energy averaged (L_{eq}) noise levels for each 1/3-octave bandwidth over the entire three-minute analysis period (Figure 12).

- Unweighted 1/3 octave noise levels for the one-second interval with the highest overall C-weighted sound level, which occurred at 09:22:51h at Ugak Island (Figure 13).

FIGURE 11

UNWEIGHTED MAXIMUM (L_{MAX})
1/3-OCTAVE NOISE LEVELS FOR UGAK ISLAND



All three of the graphs show that the majority of overall energy is contained in the low frequency range between 63 and 250 Hz. The maximum 1/3-octave noise level during the analysis period was 90.5 dB (linear) at 125 Hz. The maximum 1/3-octave L_{eq} was 76.6 dB (linear) at 125 Hz. Finally, a 1/3-octave noise level at 125 Hz of 87.9 dB L_{eq} and 90.1 dB L_{max} (linear) occurred during the one-second maximum peak level of 105.6 dBC.

FIGURE 12

UNWEIGHTED 1/3-OCTAVE ENERGY AVERAGE (L_{EQ}) NOISE LEVELS AT UGAK ISLAND

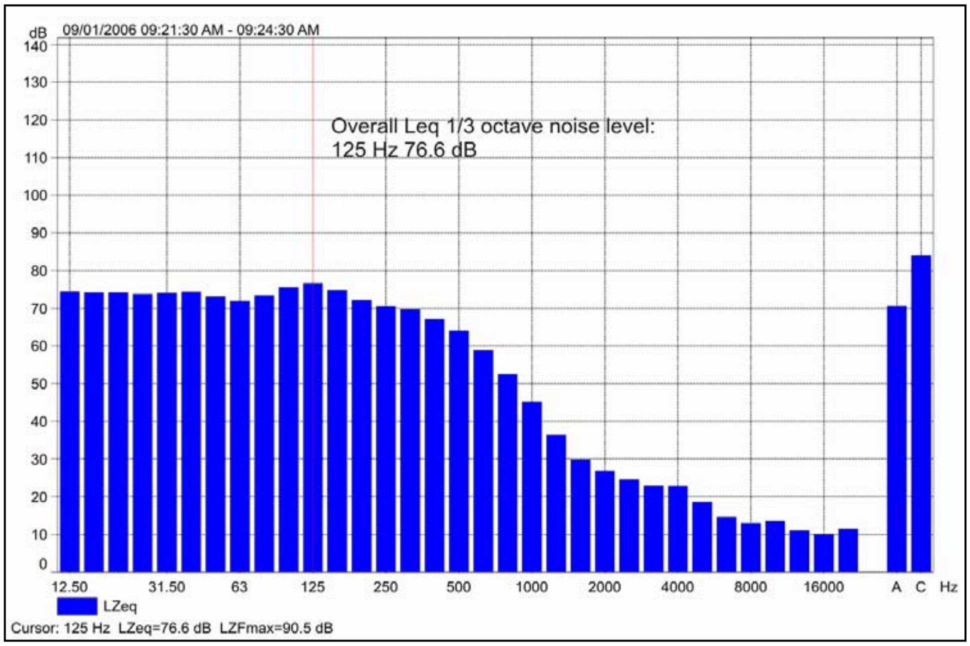
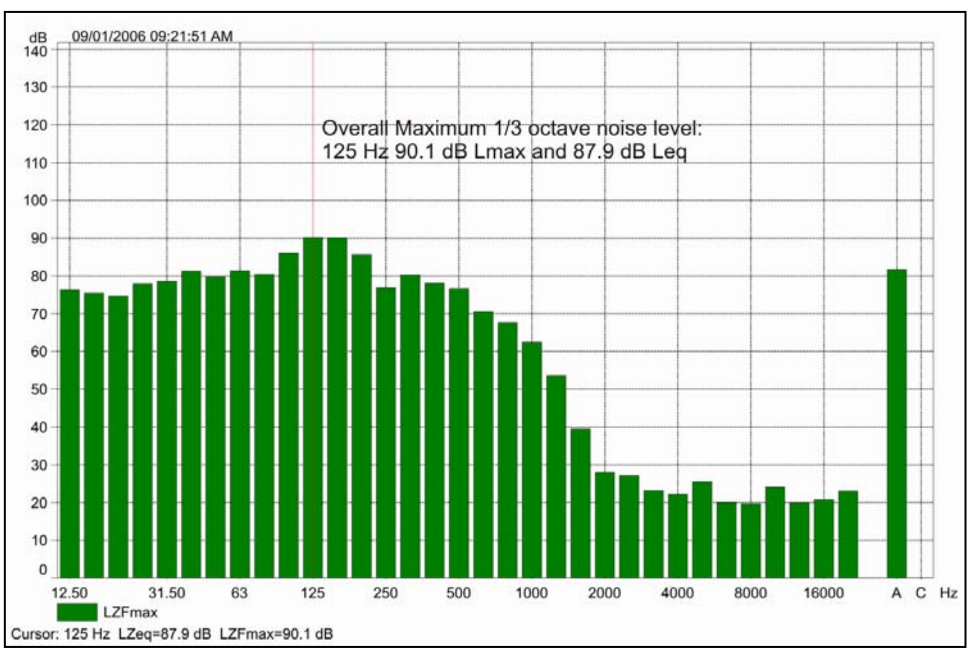


FIGURE 13

UNWEIGHTED 1/3-OCTAVE C-PEAK MAXIMUM NOISE LEVELS AT UGAK ISLAND



3.4 Discussion

Two separate evaluations of the effects of the FTG-02 launch on marine mammals were conducted. Daily counts of harbor seals were recorded from digital images taken on aerial surveys over haulouts, and a small haulout for Steller sea lions was simultaneously monitored with a sound level meter and time-lapse camera system. No discernible effects on the two species are apparent with data from this launch.

3.4.1 Steller Sea Lions

Compared with harbor seals, relatively few Steller sea lions (0 to 8 animals) were observed in the primary study area. Nonetheless, video recordings showed two Steller sea lions resting on East Ugak Rock haulout during the launch. No change in the activity of the sea lions was observed during the ignition, during the peak noise levels that followed the launch by 51 seconds or during the remaining four hours and seven minutes that they were recorded on video that day (Table 4). The number of sea lions occupying the haulout declined the day before the launch from eight to zero in an incremental pattern and timing that strongly suggested the incoming tide was reducing the available space on the haulout. Therefore, no effects from the FTG-02 launch were observed in the activity or use of the haulout by Steller sea lions. The traditional haulout on the gravel spit on the northern tip of Ugak Island was not used by sea lions during the February or September 2006 launches (FT 04-1 and FTG-02, respectively). This haulout is used only seasonally by non-breeding sea lions (Wilbor and Tande, 1998). However, it was occupied by 60 to 70 sea lions in September 1999 during the *ait*-2 launch (ENRI, 2000). Due to recorder failure, the haulout was not video recorded during that launch, so no information was collected on how that launch affected a larger haulout of sea lions (ENRI, 2000). A rocket launch in California apparently had little effect on a portion of 335 to 669 California sea lions (*Zalophus californianus*) that were observed while hauled out on San Miguel Island, but a sonic boom from the rocket did lead to 60 sea lion pups that were not part of the behavior sample entering the ocean (Berg et al., 2001). Steller sea lions react to a variety of natural and anthropogenic stimuli by fleeing into the water from haulouts (Sandegren, 1969; Porter, 1997), so reactions to rocket launches and associated noise might be expected. However, observations of helicopter and fixed-wing aircraft overflights and approaches during the FTG-02 launch monitoring elicited no change in haulout use recorded on video (see Table 4). Similar observations of unaffected sea lion behavior during helicopter flights and personnel activity at the haulout on the northern spit of Ugak Island were made during a previous monitoring study in 1999 (ENRI, 2000). These observations suggest that Steller sea lions may be tolerant of human disturbance and noise at times (this study and ENRI, 2000), but reactive to human, natural (e.g. birds), or unobserved stimuli at other times (Sandegren, 1969; Calkins and Pitcher, 1983; Porter, 1997). Thus, the reactions of Steller sea lions to disturbance stimuli are highly unpredictable.

3.4.2 Harbor Seals

Conditions were nearly ideal for documenting the maximal number of harbor seals hauled out at Ugak Island during the FTG-02 launch campaign in August and September 2006. Counts of haulouts were performed daily on aerial surveys conducted within two hours of the daytime low tide, so that tide level would be consistent among surveys. Surveys also were scheduled to occur near solar noon. Previous research has found that haulout use by harbor seals in rocky intertidal areas is highest during the daily low tide and at midday (Frost et al., 1999; Boveng et al., 2003; Small et al., 2003; and Ver Hoef and Frost, 2003). The further from these times that surveys are conducted at rocky haulouts (e.g. Ugak Island), the greater the decline in seal counts. Digital photographs of haulouts were taken to improve the accuracy of the marine mammal counts; results during the FT 04-1 launch found that visual counts from an aircraft underestimated the numbers in large groups on haulouts by 8 to 54% of the number in the photographs (R&M, 2006). Photography is routinely used for seal counts at haulouts (Frost et al., 1999; Boveng et al., 2003; and Small et al., 2003). All surveys during August 2006 produced photographs that were countable. Our ability to schedule aerial surveys around the time of highest attendance at harbor seal haulouts and consistent high-quality photography of dense haulout aggregations generated high counts with relatively low variation.

The numbers of harbor seals recorded at Ugak Island in February and August–September 2006 were higher than counted on previous launch surveys, where 0 to > 300 seals were observed. However, counts during launch surveys before 2006 were opportunistic visual tallies and were not always timed during maximal haulout use (ENRI, 1999, 2000, 2001, 2002a, 2002b, 2005a, 2005b; R&M, 2006). In 2006, numbers peaked at 682 seals during February and 961 seals during August and September. Numbers were higher during August and September because they were conducted during the annual molt, when maximal numbers of seals tend to haulout (Calambokidis et al., 1987). The high counts in 2006 represent an increase over counts of harbor seals at Ugak Island from the recent past. In the mid-1990s, 300 to 400 seals used Ugak Island (Wynne, 1995 personal communication cited in Brown and Root [1996]). In 1997, aerial surveys of haulouts were conducted monthly during baseline studies, and the highest counts were obtained with photographs taken in July (566 seals during low tide) and August (352 seals during high tide) (Wilbor and Tande, 1998). Regional population trends may have contributed to higher counts at Ugak Island in 2006. The number of harbor seals in the Kodiak Archipelago declined by 85% from 1976 to 1988, but recent data suggest harbor seals in the Kodiak area have increased by 6.6% annually from 1993 to 2001 (Small et al., 2003; Angliss and Outlaw; 2005).

The highest number of harbor seals (961) occurred on the launch day at 13:51h, 4 hours and 29 minutes after the launch. The previous count, on 31 August 2006, was 901 harbor seals. The aerial surveys were not designed to document the reaction of harbor seals to launches, and we have no data to indicate whether harbor seals left the haulouts in response to the launch. The measured noise level at the Ugak Island monitoring site during the launch was close to what was probably the ambient noise level at the harbor seal haulout. No data on ambient noise levels at the haulout sites are available, and ambient levels at the monitoring location (approximately 300 feet elevation and 460 feet from shore) do not reflect noise from wave action at the haulout sites. Ambient noise measurements of California surf were approximately 82 dB at 400 Hz (measurements by BBN [1960], shown in Figures 10.8 and 10.9 in Richardson et al., 1995), whereas the maximum launch noise levels at the Ugak Island monitoring site measured 85 dB at 400 Hz (Figure 11). Based on these estimates of ambient and launch noise, the difference in noise levels at the haulout may have been too small to cause a startle reaction.

The numbers of harbor seals at the haulouts during our surveys indicate that the launch did not have an obvious effect on haulout occupation, and that daily peak attendance at the haulouts was not affected negatively. A launch of a Delta II rocket in California caused 12 harbor seals to flee a haulout, but the seals began returning within two minutes of the launch, and numbers on the haulout returned to normal within 30 minutes (Thorson et al., 1999). Other launches at the same site in California were not linked to declines in use of haulouts (Francine et al., 1998; Thorson et al., 2000a, 2000b; Berg et al., 2001). Although the launch noise at these California haulouts generally was louder than at Ugak Island, due to larger rockets being launched from locations nearer to the haulouts in California, haulout attendance there was reported to vary more with time of day, ocean conditions, and recreational activity than with the timing of rocket launches. The observations made in California combined with the observations at Ugak Island demonstrate that these specific rocket launches and associated noise levels have effects on haulout use by harbor seals that range from none to short-term in duration.

3.4.3 Other Marine Mammals

Marine mammals other than sea lions and harbor seals, although observed and recorded, were not specifically targeted by the aerial survey and other monitoring efforts for this launch. Low numbers of sea otters were counted during the aerial surveys. However, aerial surveys for sea otters are more effectively flown at 300 feet ASL, as opposed to the surveys flown at 500 feet ASL under the current methodology, and generally transects should sample shallow coastal areas to better sample sea otter habitat. Therefore, sea otters almost certainly were undercounted on the aerial surveys. Whales also were counted in small numbers, but they also were not specifically targeted for aerial survey or other monitoring during this launch campaign.

3.4.4 Launch Noise Level Comparison

Comparisons were made of the measured noise levels from the FT 04-1 launch on 23 February 2006 and the FTG-02 launch on 1 September 2006 using the L_{max}, L_{peak}, and SEL measurements. The L_{eq} and L_{min} measurements were not used, because they are very dependent on the wind velocity at the time of the rocket launch. Overall noise levels between the two launches were very similar, and any differences were likely due to atmospheric conditions. At the Narrow Cape monitoring site the SELs for both launches were within 0.1 dBA (112.6 in February and 112.5 in September). The L_{max} noise levels at the Narrow Cape site were 106.9 dBA in February and 110.0 dBA in September.

At the Ugak Island monitoring site, the SEL ranged from 88.9 dBA to 92.3 dBA in February, and ranged from 89.8 dBA to 90.3 dBA in September. L_{max} noise levels at Ugak Island were measured at 86 dBA in February and 83.1 dBA during the September launch. Again, differences of this magnitude are likely due to atmospheric conditions, which can have a large effect over the distances (4.2 miles in February and 4.6 miles in September) between the launch vehicles and the locations of the noise monitoring system at Ugak Island.

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APPENDIX A

PHOTO LOG

Oblique overview of Kodiak Launch Complex, facing northeast (AADC File Photo).

Remote camera view of FTG-02 launch, facing west
(Photo Courtesy of Sandia National Laboratories).

Pre-launch water quality monitoring at Stream 2, facing northeast.
28 August 2006.

Typical landing zone, Ugak Island.
30 August 2006.

Time-lapse video camera (right) and noise monitor (left) being deployed on Ugak Island.

View of "East Ugak Rock" Steller sea lion haulout from time-lapse video camera location on east side of Ugak Island. 30 August 2006.

Close-up photograph of “East Ugak Rock”, as seen from Ugak Island.

Oblique aerial photo of portion of harbor seals at the southeast haulout on Ugak Island.
31 August 2006.

Oblique aerial photo of portion of harbor seals at the northeast haulout on Ugak Island.
31 August 2006.

APPENDIX B

CONDITIONS DURING MARINE MAMMAL AERIAL SURVEYS

APPENDIX B

CONDITIONS DURING MARINE MAMMAL AERIAL SURVEYS

Date	Start Time (ADT)	End Time (ADT)	Low Tide Time [a]	Tide Height (feet) [b]	Wind Speed (mph)	Wind Direction	Wave Height (feet)	Cloud Cover (%)	Visibility	Precip.	Comments
28 Aug 06	10:27	11:05	10:38	1.2	8	NW	1	20	unlimited	none	
29 Aug 06	10:01	10:39	11:04	1.8	5	W	1	80	unlimited	none	high thin clouds
30 Aug 06	–	–	11:33	2.5	–	–	–	100	0.25–0.5 mi	fog/rain	no survey
31 Aug 06	11:48	12:26	12:07	3.1	15	NW	2–3	100	5 mi	occ. lt. rain	
1 Sep 06	13:41	14:18	13:00	3.7	12	NW	2–3	95	unlimited	none	turbulent at Ugak I.
2 Sep 06	12:41	13:20	14:32	4.0	4	NW	1–1.5	95	unlimited	none	
3 Sep 06	14:04	14:44	16:15	3.8	15	NW	1–2	98	10 mi.	mist–lt. rain	turbulent at Ugak I.

Key: [a] Local daylight savings time of low tide nearest to survey time from Ugak Bay (Saltery Cove) predictions: NOAA CO-OPS (http://140.90.121.76/cgi-bin/get_pred.cgi?year=2006&stn=7292+Kodiak&secstn=Ugak+Bay+(Saltery+Cove)&thh=-0&thm=29&tlh=-0&tlm=20&hh=-0.3&hl=-0.1).

[b] Tide height is referenced to mean lower low water.

APPENDIX C

COUNTS OF MARINE MAMMALS ON AERIAL SURVEY TRANSECTS, INCLUDING PORTIONS OUTSIDE THE PRIMARY STUDY AREA

APPENDIX C

COUNTS OF MARINE MAMMALS ON AERIAL SURVEY TRANSECTS, INCLUDING PORTIONS OUTSIDE THE PRIMARY STUDY AREA

Date	Steller Sea Lion	Harbor Seal [a]	Sea Otter	Gray Whale	Humpback Whale	Unidentified Whale
Pre-launch						
28 Aug 06	3	716	0	0	0	4
29 Aug 06	4	884	4	0	0	0
31 Aug 06	5	1,154	0	0	0	0
Post-launch						
1 Sep 06	2	1,132	1	0	0	0
2 Sep 06	1	1,134	0	3	1	0
3 Sep 06	1	943	2	0	1	0
Total	16	5,963	7	3	2	4
Mean	2.67	993.83	1.17	0.50	0.33	0.67
Std. Error	0.67	72.16	0.65	0.50	0.21	0.67

Notes: Counts from digital images at haulout sites and visual tallies elsewhere during pre- and post-launch aerial surveys, Kodiak Island, Alaska, 2006. Transects and primary study area boundary shown in Figure 4. Marine mammal locations shown in Figure 5.

Key: [a] Includes counts from photos of haulouts; all other are visual counts from the aircraft

APPENDIX D

TECHNICAL NOTE:

Acoustics Introduction

TECHNICAL NOTE: ACOUSTICS INTRODUCTION

General Introduction

Sound is any change in air pressure that the human ear can detect, from barely perceptible sounds to sound levels that can cause significant hearing damage. These changes in air pressure are translated to sound in the human ear. The greater the change in air pressure, the louder the sound. The unit used to measure the loudness of sound is called a decibel (dB). A range from 0 to 120 dB is the typical range of hearing.

In addition to loudness, frequency is a term also used to describe sound. The frequency of sound is determined by the number of recurring changes in air pressure per second. A sound that contains a relatively high number of pressure changes per second is generally referred to as high frequency or "high-pitched". One common example of a high-frequency sound is a referee's whistle. A sound that has a low number of pressure changes per second is referred to as low frequency or low-pitched, for example a bass drum. The unit used to measure the frequency of sound is called hertz (Hz). While the human ear can detect a wide range of frequencies from 20 Hz to 20,000 Hz, it is most sensitive to sounds at the middle frequencies (500 to 4,000 Hz). The human ear is progressively less sensitive to sound at frequencies above and below this middle range. For example, a noise level of 60 dB at 250Hz would be considerably less noticeable to a person than 60 dB at 1,000 Hz.

A person's response to sound is subjective and can vary greatly from person to person. Some key factors that can influence an individual's response include the loudness, frequency, the amount of background noise present, and the nature of the activity taking place that is affected by the sound. When sounds are unpleasant, unwanted, or disturbingly loud, they are normally considered "noise".

Acoustic Weighting Scales

To account for the human ear's sensitivity to frequencies, an adjustment is made to the dB measurement scale. The adjusted scale, referred to as the A-weighted decibel scale, provides a more accurate measure of what the human ear can actually hear. When the A-weighted scale is used, the decibel levels are designated as dBA.

In addition to the A-weighting scale, there are other weighting scales. Another commonly used scale is the C-weighting scale. The main difference between the "A" and "C" scales is the weighting on lower frequencies. The C-weighting scale was developed to better represent high-energy, low-frequency noise sources such as blasting, helicopters and space launch vehicles. To accomplish this, the C-weighting scale does not reduce the low frequency noise levels to the same extent as is done by the A-weighting filter. For example, the A-weighting scale reduces noise at 100 Hz by 19.1 db, while the C-weighting scale only reduces 100 Hz noise level by 0.3 dB. Figure D-1 provides a graph of the A- and C- weighting curves for comparison.

The in-air sensitivity of harbor seal hearing declines below 2,000 Hz (Richardson et al. 1995). Pinniped hearing, in general, is less sensitive than human hearing at frequencies below 10,000

Hz. Therefore, the A-weighting scale is better than the C-weighting scale at measuring the frequencies to which pinnipeds are sensitive.

Noise Level Perspective

For a sense of perspective, normal human conversation ranges between 44 and 65 dBA when people are about 3 to 6 feet apart. Very slight changes in noise levels, up or down, are generally not detectable by the human ear. The smallest change in noise level that a human ear can perceive is about 3 dBA, while increases of 5 dBA or more are clearly noticeable. For most people, a 10 dBA increase in noise levels is judged as a doubling of sound level, while a 10 dBA decrease in noise levels is perceived to be half as loud. For example, a person talking at 70 dBA is perceived as twice as loud as the same person talking at 60 dBA.

In most neighborhoods, nighttime noise levels are noticeably lower than daytime noise levels. In a quiet rural area at night, noise levels from crickets or winds rustling leaves on the trees can range between 32 and 35 dBA. As residents start their day and local traffic increases, the same rural area can have noise levels ranging from 50 to 60 dBA. While noise levels in urban neighborhoods are louder than rural areas, they share the same pattern of lower noise levels at night than during the day. Quiet urban nighttime noise levels range from 40 to 50 dBA. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA.

Long term, or continuous, exposure to very loud noises can significantly damage the human ear. To protect against hearing loss, the USEPA has established an 8-hour continuous exposure limit of 75 dBA. Noise levels exceeding 80 dBA over continuous periods can result in permanent hearing loss. Noise levels above 110 dBA become intolerable and then extremely painful, and noise levels over 140 dBA can cause instantaneous hearing damage.

Table D-1 shows some common noise sources and compares their relative loudness to that of an 80 dBA source, such as a garbage disposal or food blender.

TABLE D-1

SOUND LEVELS AND RELATIVE LOUDNESS OF TYPICAL NOISE SOURCES

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horse power siren (100 feet)	130		32 times as loud
Loud rock concert near stage, Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal, food blender (2 feet), Pneumatic drill (50 feet)	80	Moderately loud	Reference loudness
Vacuum cleaner (10 feet), Passenger car at 65 mph (25 feet)	70		1/2 as loud
Large store air-conditioning unit (20 feet)	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic Test Chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and USEPA (1971).

Measurement Descriptors

Noise levels from most sources tend to vary with time. For example, noise levels increase when a car approaches, then reach a maximum peak as it passes, and decrease as the car moves farther away. In this example, noise levels within a one-minute timeframe may range from 45 dBA as the vehicle approaches, increase to 65 dBA as it passes by, and return to 45 dBA it moves away. The L_{max} is the maximum Root-mean-square (RMS) of noise levels over a preset measurement period. In the example above, the L_{max} of the vehicle pass-by would be 65 dBA. The L_{min} is similar to the L_{max}, but represents the lowest noise level over the measurement period. There is also a descriptor called the L_{peak}. The L_{peak}, like the L_{max},is the maximum noise level. However the L_{max} is the RMS level, whereas the L_{peak} is the absolute maximum noise level.

To account for the variation in loudness over time, a common noise measurement is the equivalent sound pressure level (L_{eq}). The L_{eq} is defined as the energy average noise level, in dBA, for a specific time period (for example, 1 min). Therefore, assuming the energy average noise level was 60 dBA during the entire period of time the car could be heard as it passed by, the noise level would be stated as 60 dBA L_{eq}.

Several other noise level descriptors can be used to quantify noise levels. Many of these, such as the L_{dn} and the community noise equivalent level (CNEL), are primarily designed for use with residential communities and are based on the L_{eq} (described above). Other noise level metrics measure whether a noise source is continuous or short-term in nature.

The SEL (sound exposure level) is defined as the constant sound pressure level in dBA lasting for one second that has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T. Using the vehicle pass-by as an example, the SEL for this event would be the same amount of acoustic energy in one second that the car produced during the entire pass-by. Therefore, the SEL would be a decibel level that is much higher then the L_{eq} or the L_{max}, and for the given example would likely be 70 to 75 dBA. The SEL provides a reference noise level for a specific noise event and allows for a direct comparison of several different events based on acoustical energy.

Sound Attenuation

There are several factors that determine how sound levels decrease over a distance. Under ideal conditions, a point noise source in free space will attenuate at a rate of 6 dB each time the distance from the source doubles, according to the inverse square law. An ideal line source, such as constant flowing traffic on a busy highway, reduces at a rate of approximately 3 dB each time the distance doubles. Under real-life conditions, however, interactions of sound waves with the ground often result in attenuation that is slightly higher than the *ideal* reduction factors given above. Other factors that affect the attenuation of sound with distance include existing structures; topography; foliage; ground cover; and atmospheric conditions such as wind, temperature, and relative humidity.

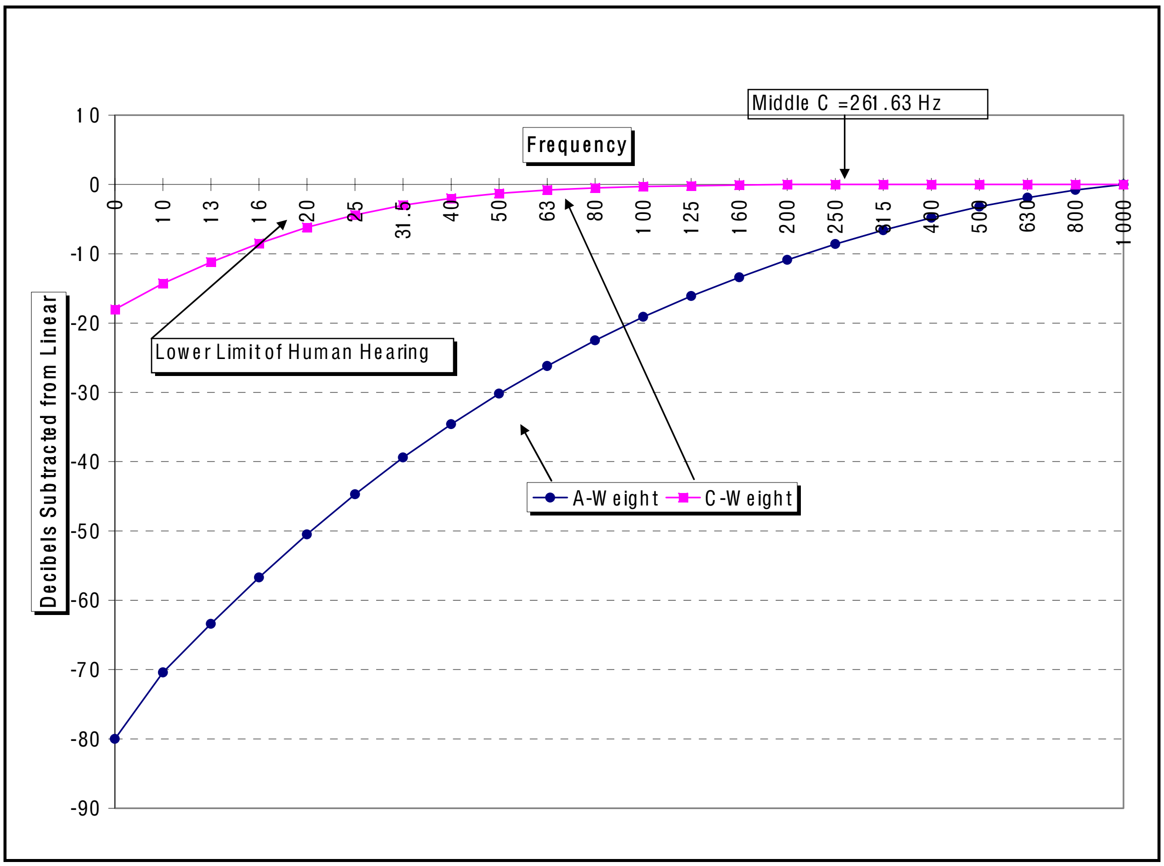
NOISE MEASUREMENT TECHNICAL DESCRIPTIONS

A-weighting and C-weighting Curves

Figure D-1 is a plot of the A-weighting and C-weighting curves for comparison. As is shown, the C-weighting curve does not reduce low-frequency noise as much as the A-weighting curve.

FIGURE D-1

A-WEIGHTING AND C-WEIGHTING CURVES



Definitions of Noise Measurement Metrics

The following section provides a technical description and definitions of the most common measurement descriptor. The information is divided into three sections: General Measurement Metrics; Community Measurement Metrics; and Statistical Measurement Metrics.

General Measurement Metrics

- **L_{pA} (A-weighted sound pressure level).** The sound pressure in dB is 20 times the log of the ratio of the measured A-weighted pressure, p, to the static pressure, p_o, where p_o is 20 μPa.

$$L_{PA} = 20\mathrm{Log}_{10}\left(\frac{p_A}{p_0}\right) dBA \;\; re\ 20uPa$$

- **L_{eq} (equivalent continuous sound level).** The constant sound level in dBA that, lasting for a time "T," would have produced the same energy in the same time period "T" as an actual A-weighted noise event.

$$L_{eq} = 10\mathrm{Log}_{10} \frac{1}{T} \int_0^T \left(\frac{p(t)}{p_o}\right)^2 dt$$

- **L_{min} (minimum A-weighted RMS sound level).** The smallest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.
- **L_{max} (maximum A-weighted RMS sound level).** The greatest RMS (root-mean square) sound level, in dBA, measured during the preset measurement period.
- **L_{peak} (maximum absolute sound level)** The greatest absolute sound level, in dB (linear, A- or C-weighting), measured during the preset measurement period.

Community Noise Level Descriptors

The following sound level descriptors are commonly used in community noise measurements:

- **L_{dn} (day-night average sound level).** A 24-hour equivalent continuous level in dBA where 10 dB is added to nighttime noise levels from the hours of 10:00 p.m. to 7:00 a.m.
- **CNEL (community noise equivalent level)**. A 24-hour equivalent continuous level in dBA where 5 dBA is added to evening noise levels from 7:00 p.m. to 10:00 p.m. and 10 dBA is added to nighttime noise levels from 10:00 p.m. to 7:00 a.m.
- **SEL (sound exposure level)**. That constant level in dBA that, lasting for 1 second, has the same amount of acoustic energy as a given A-weighted noise event lasting for a period of time T. This measurement is most commonly used for airport noise and to establish reference noise levels.

Statistical Noise Level Metrics

Public response to sound often depends upon the range that the sound varies in a given environment. For example, people generally find a moderately high, constant sound level more tolerable than a quiet background level interrupted by high-level noise intrusions. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a given time period. Such distributions identify the sound level exceeded and the percentage of time exceeded; therefore, it allows for a more complete description of the range of sound levels during the given measurement period.

The sound level descriptor L_{XX} is defined as the sound level exceeded XX percent of the time. Some of the more common versions of this descriptor and their corresponding definitions are listed below:

- **L_{01}:** The sound level is exceeded one percent of the time. This is a measure of the loudest sound levels during the measurement period. Example: During a one hour measurement, an L_{01} of 95 dBA means the sound level was at or above 95 dBA for 36 seconds.
- **L_{10}:** The sound level is exceeded 10 percent of the time. This is a measure of the louder sound levels during the measurement period. Example: During a one hour measurement, an L_{10} of 85 dBA means the sound level was at or above 85 dBA for six minutes.
- **L_{50}:** The sound level is exceeded 50 percent of the time. This level corresponds to the median sound level. Example: During a one hour measurement, an L_{50} of 67 dBA means the sound level was at or above 67 dBA for 30 minutes.
- **L_{90}:** The sound level is exceeded 90 percent of the time. This is a measure of the nominal background level. Example: During a one hour measurement, an L_{90} of 50 dBA means the sound level was at or above 50 dBA for 54 minutes.